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STATUS OF VIDOJEVICA 20 YEARS AFTER ITS FOUNDING

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Abstract. Astronomical station Vidojevica was founded almost 20 years ago, i.e. in 2003. In this paper, we will present the twenty-year history of our station, its current status and future plans. Knowing about the plan to purchase a 1.5m telescope for the Rozhen observatory, we will especially refer to our 1.4m Milanković telescope, which was purchased from the same company - Astro Systeme Austria. Current observation projects and how to apply for the use of our telescopes will be also described.

1. INTRODUCTION

The Astronomical observatory in Belgrade (AOB), on the Zvezdara hill, had several excellent optical telescopes for observation in Yugoslavia at the time. Unfortunately, due to increasing light pollution, observations have become almost meaningless on most of our telescopes in the late 1980s. Only the high resolution Solar spectrograph was in regular use, the others being used only for educational and/or recreational observations. This led the management of the observatory to plan the construction of a new observation station. Around that time, extensive testing of various sites on observation conditions (seeing, sky transparency, etc.) began.

Due to historical circumstances, the implementation of the plan for the construction of a new station was full of challenges, so the location for the new observatory was defined and formalized only in 2003, when the property for the construction of the observation station was obtained from the state. Today, the station has three telescopes and several good instruments that serve to plan observations and monitor weather and observation conditions.

In the next section, we will describe a brief history from 2003. to the present day. Section 2. will describe our three telescopes with the instruments currently installed on them. Chapter 3. will describe how our observatory operate, as well as the way of allocating observation time on our telescopes. The last section will give a brief overview of future plans at the observatory.

2. SHORT HISTORY OF THE ASTRONOMICAL STATION VIDOJEVICA

As we mentioned earlier, the Astronomical Station Vidojevica (ASV) was founded in 2003. It is located on the Vidojevica mountain, which, geographically speaking, is located in the south of Serbia near the town of Prokuplje. Originally, the station had a dirt road and was connected to electricity, so the construction of elementary infrastructure proceeded relatively quickly. Already in 2005, a residence building was built, a well that provides drinking water was dug, and a pavilion for a 60 cm telescope was built. The further twenty-year history of the station can be presented in the following way:

- **2005, acquisition of the first telescope**. The first telescope that was acquired was a 60cm telescope from the Astro Systeme Austria (ASA) company. By the time of delivery, in 2005, we had already acquired a pair of modern CCD cameras and a portable spectrograph.

- **2010, installation of a 60cm telescope**. Due to various obstacles, the telescope was installed and calibrated only in 2010, and the following year we started with regular observations. Of the instruments used for monitoring the weather conditions at the station (and planning observations), we acquired and installed several instruments: DavisPro meteorological station, SBIG all-sky monitoring camera, and SBIG seeing monitoring camera. Of these instruments, only the seeing monitoring camera is not in use today, but several new instruments have been acquired in the meantime: Unihedron for measuring the brightness of the sky and AAG cloud-watcher for monitoring the cloudiness of the sky.

- **2010, the BELISSIMA project**. In the desire to acquire a larger and more modern telescope, a group of scientists at AOB submitted an application to the FP7 REGPOT call of the European Commission. The project called BELISSIMA (BELgrade Initiative for Space Science, Instrumentation and Modeling in Astrophysics) was approved and officially started on July 1, 2010. BELISSIMA[1] had 5 working packages, and one, the most important, worked on the procurement of 1.5m class telescopes (e.g. Samurović and BELISSIMA collaboration (2012), Samurović (2013), Samurović (2017)).

- **2016, installation of a 1.4m telescope**. As a final result of the BELISSIMA project, the telescope was procured from the ASA company, and it was delivered in May 2016. The telescope is installed in a pavilion with a sliding roof that was built for the temporary accommodation of the telescope. Thanks to the clear nights after the installation, the telescope was soon calibrated and put into operation.

[1] http://belissima.aob.rs/

- 2018, moving the 1.4m telescope to its pavilion. Shortly after the installation of the 1.4m telescope, we started planning the construction of pavilion for the 1.4m telescope, the construction of which was completed in the middle of 2018 by a company from Serbia, while the dome was purchased from the Italian company Gambato[2]. After transferring the telescope to the pavilion, we soon started calibrating the telescope in order to again put the telescope into operation for astronomical observations as quickly as possible. This year was also marked by the formation of the commission for time allocation on our two telescopes, an obligation that was defined in the BELISSIMA project. In the same year, the ASV 60 cm telescope was moved to a pavilion with a sliding roof.

- 2020, installation of the 40cm telescope. The Meade 40cm telescope was acquired back in 2004, and was in use at the AOB. It was transferred to ASV in 2019 with the intention of engaging the telescope into regular observations. The building of the pavilion was made by a company from Serbia, the same one that was engaged for the pavilion of the 1.4m telescope. The dome, on the other hand, was purchased from the Polish company ScopeDome[3].

- 2021, 60cm and 40cm telescope modifications. A test of the 40cm telescope showed poor tracking, so Mead's original mount was replaced with a fork mount from Gemini Telescope Design[4] company in 2021. This year was also marked by the replacement of the old 60cm telescope mounting with the DDM200 from the ASA company.

- 2022, automation of the pavilion with a sliding roof. After the decision to keep the 60cm telescope in a temporary pavilion with a sliding roof, the automation of the roof was done, so that it can now be controlled remotely.

As of the writing of this publication, ASV has three telescopes. The first one is the 1.4m telescope, which we named telescope "Milanković", after the famous

Serbian scientist Milutin Milankovic, who at one time was the director of AOB. The second telescope is a 60 cm telescope, which we named the "Nedeljković" telescope, also after the scientist who initiated the establishment of the observatory in Belgrade and who was chosen as its first director (e.g. https://www.aob.rs/Main/history.html). The third telescope is the 40cm telescope, which we unofficially call "Győrgy", after Győrgy Pál, who was the designer of the MoFoD assembly for our 40cm telescope[5]. While the 1.4m and 60cm

[2] https://www.gambato.com/

[3] https://www.scopedome.com

[4] http://www.geminitelescope.com/

[5] Győrgy Pál, of Hungarian origin, passed away in 2022. He personally installed the MoFoD mounting for our 40cm telescope at ASV, hence the initiative to call the 40cm telescope after him.

telescopes are in regular observational activity, the 40cm telescope is still in the test phase. In the following chapters, the main technical characteristics of all three telescopes will be described. Main characteristics of the site (seeing, weather conditions and so on) are described in the detail by Jovanović et al. (2012).

3. TECHNICAL CHARACTERISTICS OF THE TELESCOPES

3.1. The 1.4m Milanković telescope

The Milanković telescope is an Alt-Az mount with a Ritchey–Chrétien optical system. The diameter of the primary and secondary mirrors are about 1400mm and 460mm, respectively. Both mirrors are manufactured and tested at the LOMO company in Russia. Tertiary flat mirror enables directing the light beam to four outputs ports, two of which are Nasmith ports with a image-derotator that makes correction for image rotation in the focal plane of the ports. Effective focal distance (without additional optics) on all ports is about 11200mm. The optical system is designed to provide a 30 arcmin field of view without significant aberrations.

The telescope is powered by direct drive motors, which has numerous advantages over stepper motors. The number of parts that wear out is minimal with these engines, so their life is extended. The speed of starting and stopping the telescope is fast as well as its slewing to the celestial object (up to 6 degrees/sec). In addition, due to the small number of moving parts, the telescope is quiet when moving (admittedly, the telescope motors produces some resonant sounds that we could not remove when calibrating the telescope). Each of the motors, including the motors for the tertiary mirror, focusing with the secondary mirror and derotators, are equipped with high-quality absolute encoders. Altitude and azimuth encoders enable precise tracking (< 0.5 arcseconds in 10 minutes; tracking errors increase near the zenith, which is normal for this type of telescope mountings) and pointing (< 5 arcseconds of r.m.s pointing error).

The complete control system of the telescope is located inside the fork of the telescope and is controlled directly via the Internet. Currently, the computer is running under the Windows operating system. There is a wide variety of software that can be used to control the telescope and detector, but we have defined this selection as follows:

- **Autoslew**, is a program that is supplied by the ASA company and we use it to control the telescope. **Seqence** is another software from ASA that has various functions. Certainly the most important function of this software is the automatic creation of a pointing model, without which it would not be possible to precisely point the telescope at the given object. During regular observation we mainly use it for automatic telescope focusing, and sometimes for telescope guiding.

- **MaxImDL**[6] is the software we use to control the CCD camera and the filter wheel. It can also be used to control the telescope, and has other convenient possibilities, such as the transformation of pixel coordinates to WSC (using the PinPoint program), accurate centering of the target to the image center and so on. It allows connection to the DavisPro2 weather station, and records many meteorological parameters in the header of the FITS images.

- **ControlPanel** is a software developed by our collaborators, and it enables the control over the dome and its synchronization with the telescope. In addition to these most important functions, it also enables fan control in the pavilion, control over the humidifier, and basically control over all devices inside the pavillion remotely.

In principle, the above mentioned software packages are sufficient to run observations that are currently performed with our telescopes. However, **TheSky**[7] software is also used. It offers various functions, but we use it to take ephemeris of celestial objects in order to script observations. MaxImDL and TheSky provide an ActiveX interface that enables external control of telescopes, CCD cameras and other devices using scripting. ActiveX can be used with many programming languages (VBScript, JScript, Java, Perl, Visual Basic, Visual C++ etc.), but, in the Windows operating system, VBScript and JScript are most often used, because they can be run by the Windows Scripting Host, which is included in Windows.

As we mentioned, both Nasmith ports are equipped with an image derotator, and are used for observations (Figure 1.). Currently, one of the ports is equipped with an iKonL CCD camera and filter-wheel from the Andor company[8]. The 9-position filter-wheel is equipped with B,V,R,I standard Johnson-Cousin filters, L broad-band filter, and Ha, Ha continuum, SII narrow filters (~10nm) and are mostly used for photometric measurements and imaging.

The second port is currently equipped with two cameras and is specialized for lucky imaging of close binary stars (although, it is also used for other purposes such as tracking planetary occultation of distant stars). One camera is the iXon897 EMCCD[9] from the Andor company, which is characterized by fast recording and low readout noise. A x2 Barlow lens was placed in front of the camera to decrease the pixel scale for the Lucky imaging method. As a result, the field of view of this camera, with a pixel resolution of 512x512 pixels, is very small (~1.25 arcmin). Therefore, another CCD camera, SBIG STXL-6303[10], with a field of view of about 8.5x5.7 arcmin is installed on this port. The two cameras are used alternate-

[6] https://diffractionlimited.com/product/maxim-dl/
[7] https://www.bisque.com/product/theskyx-pro/
[8] https://andor.oxinst.com/products/ccd-cameras
[9] https://andor.oxinst.com/products/ixon-emccd-cameras
[10] https://diffractionlimited.com/product/stxl-6303/

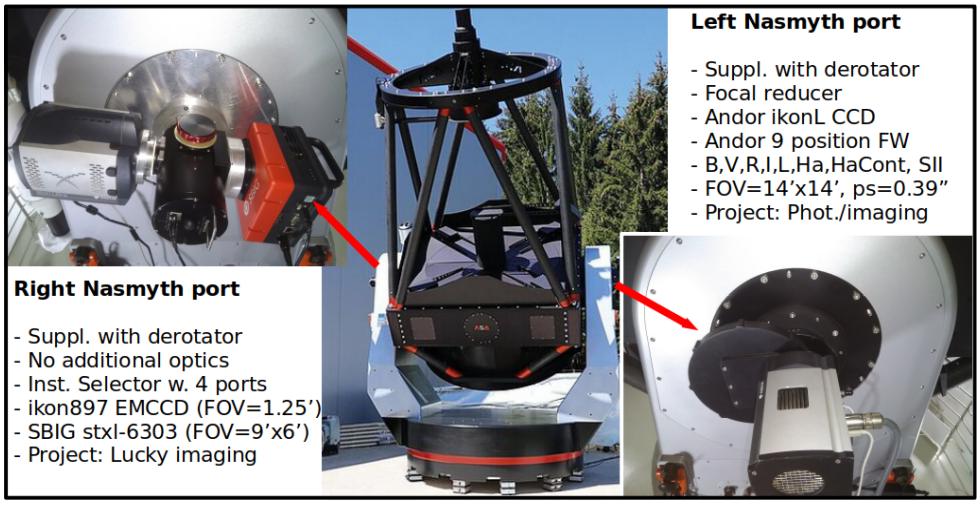

Figure 1: The 1.4m telescope (middle) and the two ports with image-derotator.

ly with the Perseus 4-Port Instrument Selector[11] from the Optec company, which may redirect the light beam to four different outputs.

At the beginning of the use of the telescope, a SpectraPro 2700 portable spectrograph was installed on this port. However, due to the large difference in the f-number of the telescope and the spectrograph, the spectrograph was only useful for the spectroscopy of bright objects, i.e., < 6-8mag (e.g. Vince et al. (2018).

Also, before the Lucky imaging instrument set, the telescope had an improvized Savart plate polarimeter installed for polarimetry testing. Except for educational purposes, this polarimeter has not entered regular use. Nevertheless, its use encouraged us to include the polarimeter in our future plans for this telescope.

3.2. The 60cm Nedeljković telescope

The 60cm telescope, later named Nedeljković, has been in operation since 2010 and there are numerous publications where details about this telescope can be found (e.g. Vince & Jurković (2012)). Here we will only briefly describe its features and current instrumental setup.

The 60 cm telescope was also purchased from the ASA company. It is an equatorial mount with a Cassegrain optical system (Figure 2.). The mirrors were also made in the LOMO factory and are of excellent quality. The theoretical focal distance of the optical system is 6000 mm. The telescope is supplied with a x0.5 focal reducer which doubles the field of view but distorts the PSF of the stars near the edge of the field of view, so it is not in a regular use. Currently, the telescope

[11] https://optecinc.com/astronomy/catalog/perseus/default.htm

is equipped with the FLI PL230 back-illuminated CCD camera[12] of Finger Lakes Instrumentation, and a filter-wheel with Johnson-Cousin B, V, R, I and SDSS u, g, r, i, z, y filters. As far as observations are concerned, photometric observations in the mentioned filters are mainly done on this telescope.

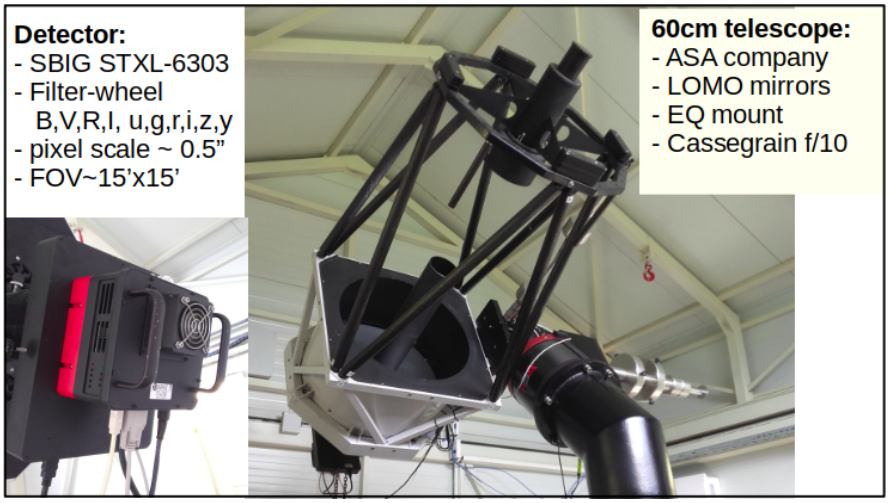

Figure 2: The 60cm telescope.

As mentioned, due to problems with the dome of the pavilion, the 60cm telescope was moved to the pavilion with a sliding roof. The telescope is optimally positioned, so that it is protected from the wind and has a good view of the sky. The pavilion has shown all its advantages (e.g. quick equalization of the temperature of the surrounding objects with the ambient temperature and stabilization of seeing) and disadvantages (e.g. rapid dewing of telescopes and instruments if the humidity in the air is relatively high), and currently there are no plans to restore the dome of the 60 cm telescope and return the telescope to the old pavilion. The pavilion has recently been automated, so remote control of the roof via the Internet is possible. Likewise, the old assembly was recently replaced with the DDM200 (made by ASA company), which is based on direct drive motor technology.

3.3. The 40cm MEADE telescope

Although the Meade 16" telescope was the first of the ASV telescopes to be acquired, it was the latest to be installed. In fact, due to the numerous problems we still encounter today, the telescope is still in the test phase. Here we will briefly describe its main features.

[12] https://www.flicamera.com/proline/

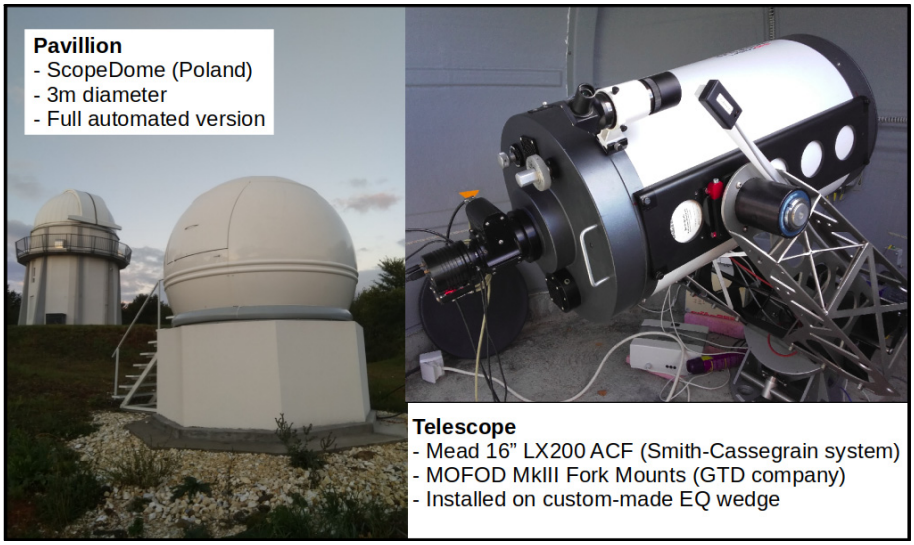

Figure 3: The 40 cm telescope.

The 40cm telescope is an older Meade product - specifically the Meade 16" LX200 ACF, with a relative aperture of f/10, i.e. a focal length of about 4000mm. The telescope is a Smith-Cassegrain optical system. It was delivered with a tripod with the aim of being used as an Alt-Az system, however, we placed the telescope on a concrete pillar and calibrated for using it as an equatorial fork system (mainly due to the intention of using it for long exposures without an image derotator).

The telescope's original mount showed very poor tracking which was probably the result of some damage to the motor and transmission system during the transport of the telescope. Therefore, a new mount was provided from the Gemini Telescope Design company- Gemini MOFOD MkIII Fork Mounts[13]. The telescope is currently equipped with the SBIG STXL-6303 camera for testing.

4. MODE OF OPERATION OF THE ASV

Currently, the number of people serving the ASV is relatively small - a manager, two technical operators and one janitor. Considering the current situation, observations are made only for 15 days around the new moon. Observations are made by astronomers who have been given time on the telescope and who receive a short training session before using the telescopes. Technical operators are responsible for the training of new observers, as well as the proper operation of telescopes and instruments that are used at a given moment.

Observation time is allocated based on applications, which are evaluated by the Time Allocation Committee (TAC). Applications are submitted twice a year.

[13] http://www.geminitelescope.com/mofod-mkii-fork-friction-mount/

On average, about 20 observing applications per semester are submitted to both telescopes. All details related to the submission of applications and the functioning of the TAC are described in the regulations that are publicly available on our official web address: http://vidojevica.aob.rs/.

5. CONCLUSIONS AND FUTURE PLANS

In the 20 years of existence of the Astronomical Station Vidojevica, it has become a productive observation station that has three telescopes fully equipped with detectors for photometric and astrometric observations. The observatory is also equipped with various instruments that are necessary for planning and conducting observations. As for the allocation of observation time and the observation itself, they follow the rules that spontaneously formed over time. Although these rules are defined in various regulations, they change over time (for example, with some major changes in the operation of the station).

As for the future plans, these are the most important ones for the near (distant) future:

- Testing of the 40 cm telescope and its introduction into regular observational work.
- A year ago, equipment was acquired for alternative supply of electricity to the station. The equipment consists of two wind generators and a network of solar panels that will be installed at the station next year. The basic idea with this equipment is to bridge long periods of time without electricity at the station.
- We have been planning instruments for spectroscopy and polarimetry for a long time. In cooperation with Russian colleagues from the Special Astrophysical Observatory, Russian Academy of Science, we created a conceptual project for an instrument that would be used as a low-resolution spectrograph and imaging-polarimeter.

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