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NEWS AND FUTURE PLANS IN THE DEVELOPMENT OF THE ASTRONOMICAL STATION VIDOJEVICA

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Abstract. Due to the new health situation that affected the whole world, the rhythm of work of the Astronomical Station Vidojevica was disturbed. However, despite this, a lot has been done for the development of the station and they will be presented in this paper. In the first place, it is the construction of the pavilion for the 40cm Meade telescope and its installation and calibration that are still in progress at the time of submission of the paper. In addition to the 40 cm telescope, we will also present news/plans related to the other two telescopes - the 60 cm telescope "Nedeljković" and the 140 cm telescope "Milanković".

1. INTRODUCTION

The Vidojevica Astronomical Station (ASV) is an observation station of the Astronomical Observatory in Belgrade (AOB), which was formed as a result of relocating observation activities from Belgrade to a light-unpolluted place. This relocation was considered as early as in 1980s of the last century, but due to the standard site testings to select the optimal location for the astronomical station and subsequent turbulent historical events, its realization came only in 2003. It was decided that the place for the astronomical station would be on summit of Vidojevica Mountain, which is located in the south of Serbia near the town of Prokuplje.

The station was established in 2003. In the beginning, mostly construction work was done i.e. the construction of a residential building, a telescope pavilion, the introduction of drinking water, internet networking, etc. Since these works are demanding, the station was ready to work only in 2010.

The first instruments procured were a 60cm telescope, several CCD cameras, with several broadband filters for photometric measurements and a portable spectrograph. Also, several auxiliary instruments were provided to aid astronomical observations - a meteorological station, a seeing monitoring camera and an all-sky camera. The 60cm telescope was finally installed at the end of 2010 and the first test measurements began. Although we started with photometric measurements on this telescope, the spectrograph was also installed on the telescope several times, however, due to technical difficulties, it was never systematically used on this telescope. The telescope was later named "Nedeljković" after the first director of the Astronomical Observatory in Belgrade, Milan Nedeljković (e.g. Todorovic & Milić (2019)).

The "Nedeljković" telescope was procured with the idea of testing the site in more detail for observational conditions and with the ultimate goal of procuring a larger telescope if the weather conditions are favorable. Although all the measurement results pointed to a quality sky for astronomical observations (mean seeing 1.5 arcsec with about 180 clear days for observation; see Jovanović et al. (2012)), the procurement of a larger telescope was not so straightforward. Finally, we succeeded in this plan through the BELISSIMA (BELgrade Initiative for Space Science, Instrumentation and Modeling in Astrophysics) FP7 project of the European Commission in 2010. The telescope that was realized through the BELISSIMA project has a diameter of the primary mirror of 1.4m and was finally installed in 2016. It was named "Milanković" after the famous Serbian scientist Milutin Milanković (e.g. Radovanac & Stojanović).

Back in 2004, we purchased a 40cm Meade telescope that had been in operation at AOB for a long time. It was relocated to ASV in 2018. Last year was dedicated to the adoption of this telescope. To that end, we purchased a pavilion with dome from the Polish company ScopeDome. The telescope has not yet been placed in the pavilion and this work, as well as its subsequent calibration, awaits us in the coming period.

In this article, we will describe all three telescopes in more detail. We will point out their current status and future plans. The current functioning of the station as well as the observation projects carried out on our telescopes will be briefly presented.

2. TELESCOPES AND INSTRUMENTS

2. 1. TELESCOPE "MILANKOVIĆ"

The "Milanković" telescope was purchased from the ASA (Astro System Austria) company in Austria. The telescope was temporarily installed in a roll-roof pavilion but was subsequently moved to a new pavilion with a rotating dome that had been built in the meantime. The test phase of the telescope lasted for a year and in that period of time we collimated the optical system, calibrated the telescope and tested the telescope in detail to some of the most important parameters. Due to the large mass of the telescope, it proved to be very stable against wind gasps in the pavilion with a sliding roof. At the same time, one of the greatest qualities of this type of pavilion has been proven, that is, the seeing was below 1 arcsec for most of the time. Figure 1. right is an image of the telescope when it was still in the ASA company.

The mounting of the telescope is AltAz and its optical system is Ritchey-Cretien with 4 ports for placing instruments - two Nasmiths ports on either side of the telescope and two ports that are orthogonal to them. Both Nasmith ports are equipped with an image derotator that compensates for image rotation in the field of view, which is a characteristic of these types of telescope mountings. The effective focal length of the telescope is 11.2m (f/8). One of the Nasmith ports was originally equipped with a corrective lens with the aim of providing the widest possible field of view without aberration (field corrector), so that its effective focal distance was somewhat smaller (about 10.5m). Later, this field corrector was replaced with a 0.64x focal reducer in order to provide the widest possible field of view, so that currently the focal distance at this port is about 7.2m. Table 1. summarizes the main features of our telescopes.

Figure 1: Left,the pavilion for the 140cm telescope. Right, the telescope while it was still in the ASA company.

The telescope is very compact. The entire telescope control system (TCS) is located inside the fork of the telescope, so the telescope is practically a plug-in device with two inputs - one for power and other for ethernet access to the TCS. The telescope mounting is a direct drive motor (DDM), so the telescope is fast and noiseless. Its maximum speed is about 6 degrees per second, but in practical operation it is set to about 4.

The rotating dome of the pavilion for this telescope was purchased from the Italian company Gambato[1]. Originally, it was delivered without automation, so we did the automation of the dome and its synchronization with the telescope later. Likewise the telescope,, the dome is also designed to be fast. Figure 1. left is an image of the the pavilion with the Gambato dome.

One of the Nasmith ports was dedicated to photometric measurements from the very beginning. Currently, the iKonL CCD camera from Andor company[2] is attached to this port in combination with filter-wheel containing standard Johnson-Cousin BVRI filters. In addition to these filters, we provided an L (Luminance) wide-band filter for observation of faint objects (e.g. Müller et al. 2019) and H_α, H_α continuum, and SII narrowband filters of 5nm for studying supernova remnants. Table 2 lists the CCD cameras that are attached to our telescopes and gives their basic characteristics that can be useful for planning observations.

The second Nasmith port with derotator was initially equipped with a SpectraPro spectrograph that was on the telescope for about a year in test function (Vince & Lalović (2005), Vince et al. (2018)). Currently, this port is equipped with a OPTEC Perseus instrument selector[3] that allows the beam to be redirected to four orthogonal outputs in order to use this port for as diverse observation projects as possible. Currently, there are two cameras attached to this port - iXon897 EMCCD from Andor company[4] and SBIG STXL-6303 from Diffraction Limited company[5]. Both CCDs are

[1]https://www.gambato.com/solutions/observatory-domes.html
[2]https://andor.oxinst.com/products/ikon-xl-and-ikon-large-ccd-series/ikon-l-936
[3]https://optecinc.com/astronomy/catalog/perseus/default.htm
[4]https://andor.oxinst.com/products/ixon-emccd-cameras
[5]https://diffractionlimited.com/product/stxl-6303/

Table 1: Main features of our telescopes. Last column lists the CCD cameras that are attached to telescopes at the time of writing the publication.

Tel.	D [mm]	F [mm]	CCD
Milanković PORT A	1400	7168	Andor ikonL
Milanković PORT B	1400	11200	Andor iXon897
Milanković PORT B	1400	11200	SBIG STXL-6303
Nedeljković	600	6000	FLI PL230
Meade LX200	400	4064	SBIG STXL-6303

Table 2: CCD characteristics attached on our telescopes. PS and FOV stands for pixel scale and field of view, respectively. Pixels of all our CCDs are square.

CCD	Resolution	Pixel size [μm]	PS ["/pix]	FOV [']
ikonL @ 140cm tel.	2048x2048	13.5	0.39	13.3x13.5
iXon897 @ 140cm tel.	512x512	16	0.29	2.5x2.5
STXL-6303 @ 140cm tel.	3072x2048	9	0.17	8.5x5.7
Pro230 @ 60cm tel.	2048x2048	15	0.28	9.4x9.4
STXL-6303 @ 40cm tel.	3072x2048	9	0.46	23.4x15.6

used for measuring orbital parameters of visual double systems using "lucky imaging" method (e.g. Pavlović et al. 2013, Cvetković et al. 2019).

We put in a lot of effort to automate the telescope "Milanković". The primary goal of telescope automation is to reduce the need for manpower working at the station but also to extend the observation cycle, which currently stands at 15 nights around the new Moon (more on this in the next chapter). We are currently working on the communication of the TCS with various instruments inside/outside the pavilion in order to protect the telescope and instruments from external (rain, wind, snow) and internal (moisture and dew) conditions. We expect that this level of automation will be completed in 2021. The next step is to automate the observations themselves, which would enable observations completely independent of people. This would fulfill our ultimate goal for this telescope, i.e. telescope robotization.

As mentioned earlier, our telescopes are currently optimized for performing photometric measurements. However, we plan to purchase a spectrophotometer for the "Milanković" telescope, which we hope will enrich the observation program on the telescope. In fact, an improvised polarimeter with Savart Plate has been already installed in 2019. for testing purposes. Testing was performed on dozens od standard polarized stars and several objects known to show a high degree of polarization (e.g. blazar 0716+714) and preliminary results showed that the telescope is suitable for performing polarimetric measurements (polarimetric accuracy 0.01% with ∼40 minutes total integration time for 14mag star).

2. 2. TELESCOPE NEDELJKOVIĆ

The "Nedeljković" telescope was also purchased from the ASA company. The diameter of the primary mirror is 60 cm. The telescops mounting is German equatorial and, unlike the 1.4m telescope, it is powered by two stepper motors. The optical system

Figure 2: Left, the roll-roof pavilion designed to temporarily house a 140cm "Milanković" telescope. Right, the 60cm 'Nedeljković' telescope, which is currently in this pavilion.

is Cassegrain with an effective focal distance 6m. The telescope was delivered with a 0.5x focal reducer, which is not used systematically for astronomical observations due to the relatively large aberrations at the ends of our CCD images. Some of the main features of this telescope is described by Vince & Jurković (2012).

As already mentioned, the telescope was installed in 2010 in a pavilion with a rotating dome made by an Serbian manufacturer. Unfortunately, the dome had malfunctions from the very beginning, due to which we often had suspensions of observation activities. Therefore, in 2018, we moved the telescope to a temporary pavilion, soon after the 1.4m telescope was transferred to the newly built pavilion. Currently, the telescope is equipped with the FLI PL230 CCD camera[6] and BVRIL filters for imaging, photometric and astrometric measurements. Figure 2. shows the telescope and the temporary pavilion in which the telescope is currently housed.

The degree of automation of this telescope (and pavilion) is much lower than with "Milanković". Moreover, due to the unreliable and inaccurate mounting, some more serious automation is not even possible. That is why we decided to replace the old equatorial mounting with a DDM (specifically the DDM200 from ASA company). We hope to accomplish this task and restart observations by the end of 2021.

As for the original pavilion for the 60cm telescope, which is now empty, we plan to replace its dome and then return the 60cm telescope. The main reason is that the 60cm telescope is relatively light and in the roll-roof pavilion it is more sensitive to wind gusts.

2. 3. MEADE 16" TELESCOPE

The Meade 16" LX200 telescope was purchased in 2004 and has been used at AOB for more than ten years. Due to light pollution in the city, the telescope has been limited to observing only very bright objects. With intent to use the full capacity of this telescope, it was transferred to ASV in 2018.

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

Figure 3: ScopeDome 3M pavilion (left) and the 16" Meade LX200 telescope (right).

The optical design of the telescope is Smith-Cassegrain, i.e. catadioptric telescope that combines a Cassegrain telescope with a Smith correction plate in front of the primary mirror of the telescope which corrects images for spherical aberration. The diameter of the primary mirror and the efective focal length of the telescope are 40 cm and 4064 mm, respectively. The telescope is originally delivered with tripod and is intended to be used as AltAz mounting. However, we will adjust the telescope to the equatorial mounting using a specially made wedge. The main advantage of equatorial mounting is that it avoids the need for a derotator.

We procured a pavilion with rotating dome for the telescope from the Polish company ScopeDome[7] and it was installed at the ASV in 2020 (specifically, "ScopeDome 3M" with a dome 3m in diameter). The pavilion is installed on a concrete pedestal which lifts the pavilion off the ground in case of a large amount of snowfall. The pedestal was built as a small building where electricity and internet were introduced following all standard regulations.

ScopeDome offers several types of domes and we have decided on a variant in which full automation of the dome is possible. Despite the good will, the telescope was not placed in the pavilion and was not put into operation due to complications in the organization of work and workers during the COVID19 pandemic. This job is also postponed for 2021. Figure 3. shows the ScopeDome pavilion (left) and the Meade 16" telescope (right).

3. STATION OPERATION

A total of four people are engaged around the station - a manager, two technical operators and one janitor. Currently, our policy is such that astronomers looking for telescope time to observe are also observers. In this sense, the main task of technical operators is to train new observers and to provide technical support during observations. With this number of technical operators, the station is active for only 15 days in the observation cycle, that is, 15 days around the new Moon. It is for these reasons (lack of technical operators and short observation cycle) that we strive to fully automate our telescopes.

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

The number of people is certainly insufficient to serve the station. The lack of professional people (electrical engineers, mechanics, etc.) who would perform regular maintenance of telescopes and instruments is most noticeable. Also, there is a lack of staff to maintain our website, which is the main source of information about ASV and a means of communication the public and the observers.

The installation of the "Milanković" telescope in 2016 led to a sharp increase of interest in using our telescopes. This certainly contributed to the need to form a time allocation commission (TAC) in 2018. Application for observation time is done twice a year. The first four months of the semester are scheduled for application submission and the remaining two for the TAC to review applications. Details related to the submission of applications are described in the roolbook on our website http://vidojevica.aob.rs. About 20 applications were submitted for the last open time and they can be classified into the following scientific categories:

- Determination of physical parameters of eclipse binary systems
- Determination of orbital parameters of close binary systems
- Study of active galactic nuclei (reverberation mapping)
- Stydy of Blazars
- Gaia photometric follow-up program
- Study of supernova remnants
- Asteroid photometry.
- Detection of dwarf galaxies and tidal stream effects

In addition to scientific research applications, we regularly have applications for education purposes. The most important one is the application for education of students (astronomers) from the Faculty of Mathematics in Belgrade and the Department of Astronomy at the Faculty of Physics in Novi Sad.

Currently, a number of applications allow us to assign entire evenings for observation to a specific observer. However, as interest in using our telescopes grows from year to year, we will innocently have to change this policy.

4. SUMMARY

In this paper, we describe the current status of ASV. A detailed description of all our telescopes is given, including the Meade 40cm telescope, which we have yet to install and activate for observations. A detailed overview of the instruments currently attached to our telescopes is given, which can help a potential observer to plan observations. Also, for each telescope, we have presented plans that we will implement as soon as the pandemic situation allows.

Unlike the organization of observation work on our telescopes, which is possible via the Internet, the organization of jobs planned for 2019 were hampered by the COVID19 pandemic. Despite that, we managed to implement several larger plans - the installation of the ScopeDome pavilion for the Meade 40cm telescope and the

automation of the 1.4m telescope "Milanković". However, many jobs have been postponed for the next period without a pandemic; first in line are installation/calibration of the 40cm telescope, replacement of the mounting for the 60cm telescope and completion of the automation of the "Milanković" telescope.

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