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THE ASTRONOMICAL STATION VIDOJEVICA: THE 60 CM TELESCOPE

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Abstract. We present the 60 cm telescope installed at the Astronomical Station Vidojevica. The telescope was mounted in September 2010, and has been in function since March 2011. The main instrumental characteristics of the telescope are discussed in this paper.

1. INTRODUCTION

The Astronomical Station Vidojevica (ASV) is located on Mt. Vidojevica, near town Prokuplje, in the southern part of Serbia. The geographical coordinates of the site are: longitude: 21^o 33' 20.4"; latitude: 43^o 08' 24.6"; elevation: 1150 m above the sea level. In the first phase of building the ASV, a smaller 60 cm telescope was installed, Polar aligned, and collimated. The telescope, Figure 1, was mounted in September 2010, and is in testing phase since March 2011. In the second phase, we plan to setup a new 1.5 m class robotic telescope - this is part of the grand ongoing project of the Astronomical Observatory of Belgrade called BELISSIMA (BELgrade Initiative for Space Science, Instrumentation and Modelling in Astrophysics). This paper will deal with basic characteristics of the 60 cm telescope.

The idea of building an observatory outside of Belgrade emerged in the 1980's, as the light pollution in Belgrade grew. The first seeing measurements were carried out on several sites in that time. The land on Mt. Vidojevica for the observatory was allocated to the Astronomical Observatory Belgrade in 2003. The living pavilion and the dome for the 60 cm telescope was finished in 2009. The observatory has an independent water supply and a wireless internet connection since 2011.

2. THE 60 CM TELESCOPE

Both, the telescope and the mount were purchased from the Austrian company "Astro Optik". The telescope is a Cassegrain system. The optical elements were produced in the LOMO company in St. Petersburg, Russia. The primary mirror is parabolic with a mechanical diameter D=60 cm and f/3 focal ratio. The secondary mirror is hyperbolic with diameter D=20 cm. Both mirrors are coated with highly reflective AlSiO2 coating. The telescope system has an effective focal length F=6000 mm and f/10 focal ratio.

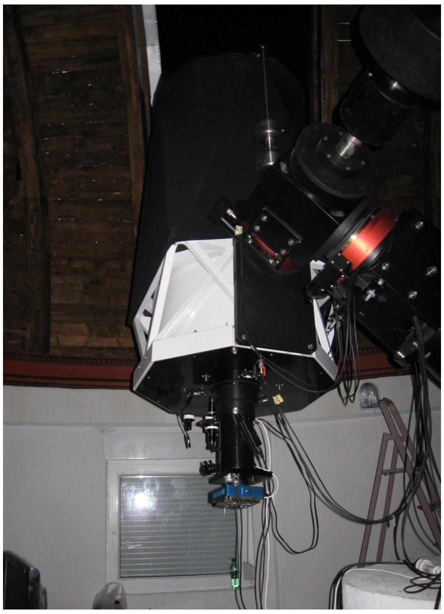

Figure 1: The 60 cm telescope.

A focal reducer was also provided for the telescope. It consists of 4 lenses organized in three groups. Each lens is MO (Molibden Oxid) coated and has a reflexity below 0.5 %. The reducer changes the focal ratio of the telescope to f/5.

The mount is German equatorial. It was installed in September 2010, but the final Polar alignment and the mirror collimation was done in June 2010. To compensate the main slewing errors (Polar alignment error, collimation error, mount error ect.) the pointing model was made on around 10 stars.

The telescope is controlled via "Autoslew". The 32bit Windows software was written by Phillipp Keller and it is compatible with the ASCOM platform (AStronomy Common Object Model). Alternatively, the telescope can be controlled using TheSky6 planetary software or MaximDL CCD imaging software. Visual Basic scripting via ActiveX is also possible. The telescope can be driven remotely too.

Several CCD cameras were provided for various observational programs. Their basic characteristics are summarized in the Table 1; FOV stands for field-of-view and are given for the telescope without focal reducer. All cameras are highly-sensitive in the optical.

For photometry we use 2 sets of 2" filters: Bessel (B, V, R, I, Clear) and Strömgren (v, b, y, Hα, Hβ). Filters are operated automatically via OPTEC Intelligent Filter Wheel.

For spectroscopy, we provided SpactraPro-750 fiber fed spectrograph, made by Princeton Instruments. The spectrograph is planed for recording 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 is still in a testing phase.

Table 1: Characteristics of CCD cameras.

CCD camera	pixel array	pixel size(μm)	FOV
Apogee Alta U42	2048x2048	13.5	15'x15'
Apogee Alta E47+	1024x1024	13	7.4'x7.4'
SBIG ST-10ME	2184x1472	6.8	8.3'x5.6'

3. TESTS

3. 1. POINTING ERROR TEST

The pointing error of the telescope was measured in three occasions: on 21^{st} August, 2011, 10^{th} September, 2011 and on 16^{th} September, 2011. In all cases, we have chosen about 10 stars, randomly distributed on the sky, and slewed the telescope. We measured the difference between two successive pointings and took the standard deviation of all differences as a measure of the pointing error. Figure 2 shows the result of the test. At the time of the testing, there was a minor problem with the alignment of the RA encoder, so the data are designated with numbers for easier identification of the outlier pointings.

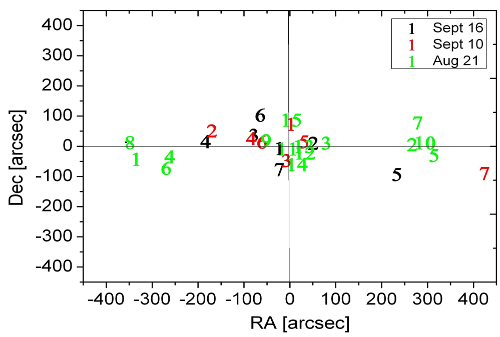

Figure 2: Pointing error measured in 3 different time periods.

Different colors correspond to different time periods of the testing as shown in the legend. The pointing errors (i.e. standard deviations) are given in the Table 2.

As can be noticed, the pointing error for both coordinates is quite large. This is especially true for the RA, reflecting the above mentioned problem with the encoder. We assume that a strong earthquake, which happened just before testing, could displace the telescope and, that the pointing model does not compensate the slewing errors any more. To conclude, there is a need for making a new pointing model for the telescope.

Table 2: Pointing error expressed in arcsec.

RMS (")	21^{st} Aug	10^{th} Sept	16^{th} Sept
RA	226.6	190.3	129.7
DEC	44.4	56.3	66.9

3. 2. TRACKING TESTS

For testing the tracking performance of the telescope, we carried out a series of continuous measurements taking images of the same object for 6 minutes, 20 minutes and 7 hours. The results are shown on Figure 3.

Tracking errors in the Dec and RA directions are designated with gray and black dots, respectively. The X axis is time in Julian Dates. The Y axis is the difference in the star position on the CCD frames relative to the first one. Knowing the pixel scale, the differences measured in pixels are converted into arcseconds; pixel scale of the CCD camera used for the tests is 0.46"/px taking into account that the telescope's effective focal length is 6000 mm.

As it can be seen from the figures, the tracking is quite stable on small time scales (below 2 arcsec for Dec and around 3 arcsec for RA for 6 minute tracking). However, there is an increasing/decreasing trend of the tracking error on longer time scales indicating again that the pointing model does not compensate the main slewing errors of the telescope so efficiently.

4. INDIRECT TESTS

There are several observational projects through which the telescope is indirectly tested. In one of the projects, faint optical counterparts of very distant radio sources were observed. We are encouraged with the result in which we saw that with stacking about 20-30 frames with 60 seconds exposure time, the telescope can reach objects down to 16-17 magnitudes with almost full moon on the opposite side of the sky (Damljanovic private communication). In a similar way, with stacking method, the telescope shot an asteroid of 18.5 magnitude. We plan to attach an auto guider to the telescope which will certainly enable us to reach much fainter objects with a less effort.

In another project, visual binary stars are observed. Preliminary results show that stellar positions can be determined very accurately, showing us that the mirrors are perfectly collimated (Stojanovic et al, in prepare). Separations as close as the seeing limit at the time of the observation are easily measured.

Differential photometry of close binaries is also an ongoing project. The bottom panel of the Figure 3 is actually a result of long continuous observation of a binary system. As can be seen, there is only about 1 arcmin difference in Dec and RA between the first and last shot in a 7 hours observation. With the 16 x 16 arcmin field-of-view of the camera that is used for the observation, one can be quite sure that he/she will find reference/checking stars that are on the frame for the whole observational time. This is important if one want to automatize the calibration/measurement procedure.

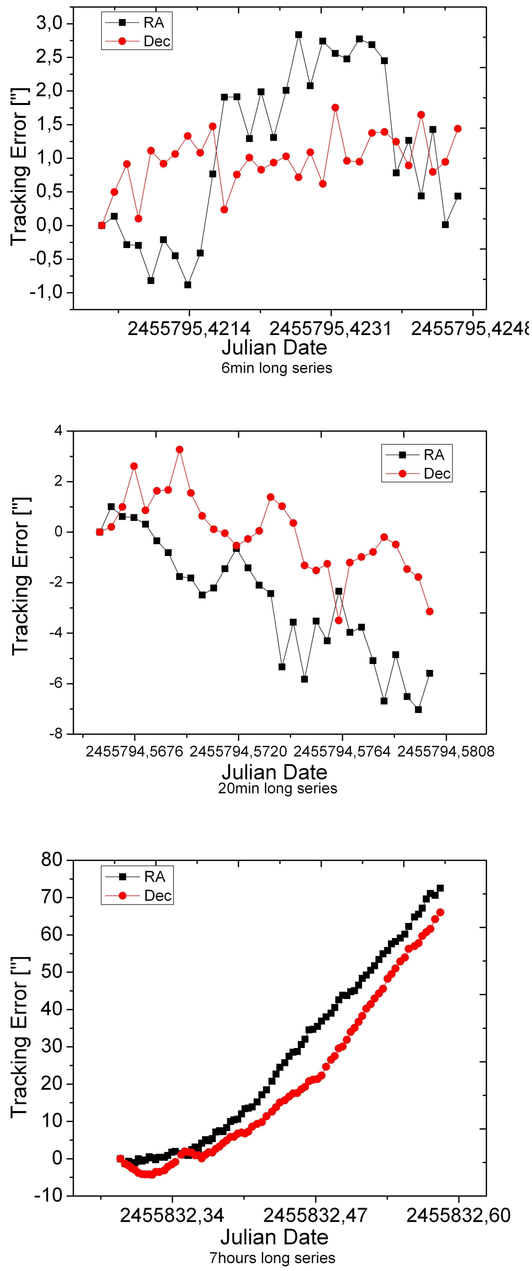

Figure 3: Tracking measured for 6 minutes, 20 minutes and 7 hours.

In one sentence, all these results validate the fact that the mirrors are of excellent quality, that the mount has an excellent tracking even without accurate pointing model, and that it can be certainly used for scientific purposes.

5. AUTOMATIZATION

Following new trends in the world, we also started with the automatization of the 60 cm telescope. The computer with the telescope control software and imaging software is in the telescope's pavilion, and it can be driven through the Local Area Network from anywhere via internet. We are still working on electro-mechanical components that will prevent any unwanted hazards of the telescope. We also work on the dome control software, as well as on the synchronization of the dome with the telescope. Automatization of the dome slit is also planned.

The camera and filter wheel are driven through the MaxImDL imaging software. This software supports scripting languages, so we are learning how to automatize the observational projects with Visual Basic scripting. Next phase would be to try the remote control of the telescope which is a probable option for controlling the new 1.5 m class robotic telescope.

6. CONCLUSIONS

In late 1980's, staff working at the Astronomical Observatory of Belgrade started with the realization of building a new observatory outside of Belgrade. After almost 30 years, the new observatory was borne. The main parts of the infrastructure are finished. The 60 cm telescope is installed, Polar aligned and collimated, and it is currently tested by several observational projects. The new 1.5 m class telescope is an ongoing project.

Basic characteristics of the 60 cm telescope were tested. Two most important are pointing accuracy and tracking. The pointing was tested in three occasions and the results show that the pointing is quite inaccurate. We suspect that the large earthquake, which happened just before the testing, is the main reason for this. A new pointing model should compensate for large errors in pointing.

Concerning the tracking error, the situation is similar. On short time scales, the tracking is quite precise, however on longer scales there is a monotonic trend in the tracking. This trend should be also removed/relaxed with a new pointing model for the telescope.

Automatization of the 60 cm telescope is underway. The telescope is currently used for both, observational projects and training of young colleagues working at the Astronomical Observatory of Belgrade to work on the automatized telescope.

Acknowledgements

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