Contrib. Astron. Obs. Skalnaté Pleso **43**, 368 – 373, (2014)

Observational projects in Serbia

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Received: October 31, 2013; Accepted: January 16, 2014

Abstract. A new era of astronomical observations in Serbia started in 2010, when a 60 cm telescope was installed on the summit of the mountain Vidojevica. Despite the small number of active observers and all the problems that usually follows the usage of a new instrument, we developed several observational projects, joined several international observational networks and follow-up projects. In this paper, we will shortly introduce all the projects and people involved in them, as well as the instruments that are used for observations.

Key words: observation – double star – blazars

1. Introduction

Except for a few, all observational projects, which were performed with the telescopes at the Astronomical Observatory of Belgrade (AOB), were terminated in late 80's because of the light pollution in the capital city. New sites were tested as potential places for a new observatory at that time. Finally, after around 20 years, the new observational site was chosen on the summit of the mountain Vidojevica - the Astronomical Station Vidojevica (ASV). In the period from 2003 to 2010, the infrastructure was constructed, different pavilions were built and a 60 cm telescope was installed along with various instruments (a meteo-station, a seeing camera, an all-sky camera).

The site is located in the southern part of Serbia at the geographical longitude $21^\circ\ 33'\ 20''.4$, latitude $43^\circ\ 08'\ 24''.6$ and at an elevation of 1150 m above sea level. The nearest town is Prokuplje with around 25000 citizens giving a little light pollution toward North. Around one third of the year is cloudless and suitable for good photometric observations. The median seeing is around 1.2 arcsecs. More details about the site and its parameters can be found in Jovanović et al (2012).

The 60 cm telescope itself is a Cassegrain system with two hyperbolic mirrors from LOMO company. Primary and secondary mirrors are 60 cm and 20 cm in diameter, respectively. Some test results on the telescope were presented by Vince & Jurković (2012). We plan to install a new 1.5m class telescope in the near future [1].

[1] See http://belissima.aob.rs/ for more details

AOB purchased several CCD cameras and two filter sets for photometric observations (BESSEL BVRI and Strongrem uvby). Some basic characteristics of the most used CCD camera is given by Vince (2012). For spectroscopic observations, on the other hand, we provided a Czerny-Turner portable spectrograph (Vince & Lalovic, 2005)

We run the telescope, CCD and the filter-wheel under a Windows operating system. All the elements are compatible with the ASCOM platform thus making possible the automatization with either Java or Visual Basic scripting languages. The dome is synchronized with the telescope.

Since the telescope was installed (2010), several observational projects have been formed. Roughly, these projects can be grouped into three categories: follow-up projects, observational networks for long-term monitoring and classical ones. In this paper, we describe all the observational projects in Serbia developed to date.

2. Observational projects

DWARF: The DWARF is a huge international project aimed at detecting circumbinary extrasolar planets using the timing of the minima of low-mass eclipsing binaries. The project is thoroughly described by Pribulla et al (2012). A small group of astronomers working at AOB joined this project in 2012. People involved in this project are: Dr. G. Djurašević, Dr. I. Vince, Dr. O. Vince., and M. Jurković.

The observational part of the project is automatized using the Visual Basic Scripting language. The whole automatization process can be roughly divided into four modules as it is schematically illustrated in figure 1. The script starts with taking calibration frames at sunset. This is followed by making master calibration frames that will be used for the reduction of taken images during the night. The "brain" of the code is the subsequent module where the code calculates which object to observe from a given list depending on the observable minima and the position of the Sun/Moon in the sky. When the object is chosen, the telescope slews to it and starts the observation. The differential photometry is measured on the fly after each exposure with a comparison star that is defined ahead. Since the photometry is calculated within a given aperture, possible shifts in the telescope slewing are constantly corrected during the observations.

Although the photometry is measured on the fly, the final light curves are calculated with the IRAF[2] reduction package. The reduction and the photometry are also automatized using IRAF scripting language.

WEBT: The WEBT (Whole Earth Blazar Network) is also a huge project created with the aim to study blazars which are characterized by strong and fast brightness variability, on time scales down to hours or less. Thanks to the

[2]http://iraf.noao.edu/

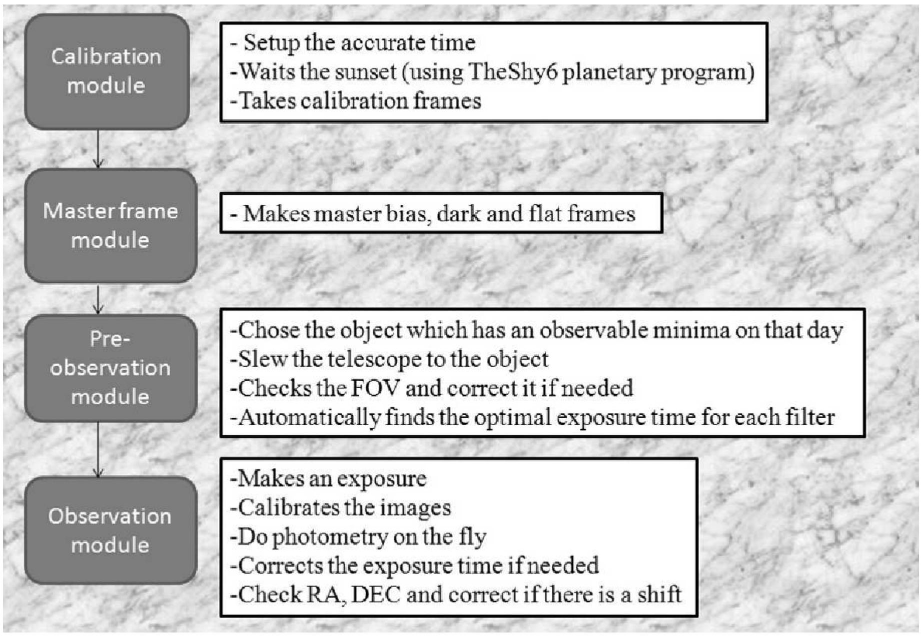

Figure 1. Automatization of the observation for the DWARF project

different locations of the telescopes all around the world, the source can be monitored 24 hours a day. These ground-based optical observations are often carried out simultaneously with observations at higher frequencies for the purpose of understanding the physical mechanisms that rule the variable emissions of these celestial objects.

The WEBT was created in 1997. In 2007, the WEBT started a new project - the GLAST-AGILE Support Program (GASP) - which provides observing support to the observations by the gamma-ray satellites GLAST and AGILE. A group of scientists working at AOB (Dr. G. Damljanović. and Dr. O. Vince) joined this project in spring 2013. The reduction and photometry procedures are automatized using the IRAF reduction package. So far, we have observed 28 blazars and participated in all observing campaigns organized since our participation.

GAIA: The GAIA is a promising space project with a micro-arcsecond global astrometry for about 1000 million stars down to 20 mag in the G band (roughly corresponding to V band). With astrometric, photometric and spectroscopic instruments onboard, GAIA will provide different scientific information.

There are several Science Alerts Working Groups formed with the aim to focus on the real-time detection of variable sources (supernovae, microlensing events, exploding and eruptive stars, etc.). These are: GSAWG1: Supernovae, GSAWG2: CVs and XRBs, GSAWG3: Microlensing, GSAWG4: Young Stars, GSAWG5: AGNs and TDEs, GSAWG6: Gamma Ray Bursts, GSAWG7: Be stars, R CrB stars and other rare events, GSAWG8: GAIA Alerts Processing and Infrastructure, GSAWG9: Spectroscopic Follow-Up and GSAWG10: Photometric Follow-Up.

We (Dr. G. Damljanović. and Dr. O. Vince) joined the Photometric Follow-Up Science Alert Group. The minimal requirements addressed to a potential follow-up observer are: multi-band photometry in at least two bands, flux calibration in Sloan u,g,r,i,z bands with a precision no worse than 0.1 mag, submission of WCS and fluxes to the Calibration Server, and availability of flux measurements within 24 hours. Because of the last mentioned requirement, the reduction and photometry procedures are completely automatized. Three large packages are used for this purpose: IRAF for data calibration and reduction, Astrometry.Net[3] to solve for WCS and Source Extractor to do the photometry measurements (Bertin & Arnouts, 1996). The whole process is illustrated in figure 2. The output is supposed to be submitted to Cambridge Calibration Server for further calibration[4].

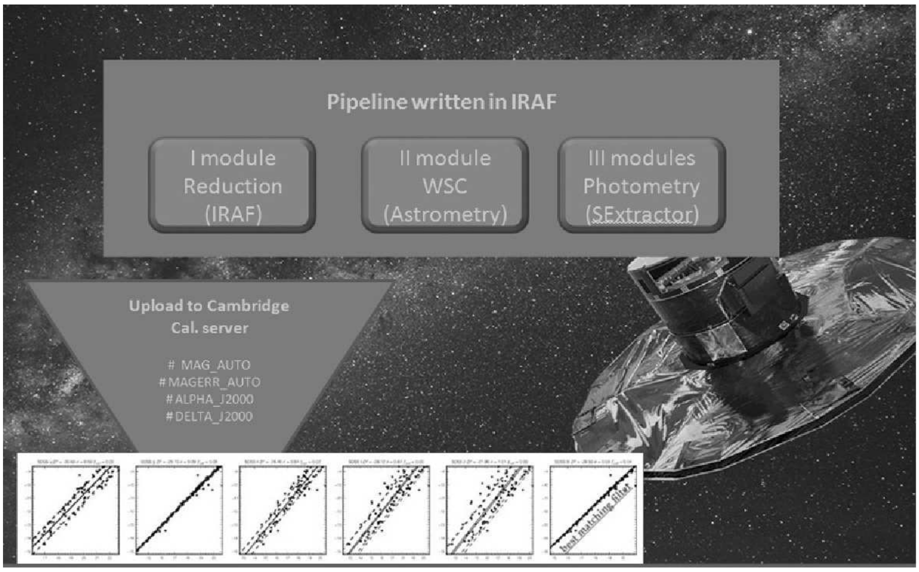

Figure 2. Automatization of the observation for the GAIA project

Classical projects: There are several observational programs that are performed within the regular scientific programme at AOB. One of them has been

[3]http://astrometry.net/

[4]See more details at http://www.ast.cam.ac.uk/ioa/wikis/gsawgwiki/index.php/Follow-up

devoted to the observers of visual double and multiple stars aimed at determining the orbital elements from measuring the position angles together with the angular separations between components. The people involved in this project are: Dr. Z. Cvetković, Dr. R. Pavlović, Dr. O. Vince and M. Stojanović. In addition to the 60 cm telescope at ASV, the 2 m telescope at the NAO Rozhen in Bulgaria is also used for observations of double and multiple stars with angular separations generally between $1\farcs8$ and $10''$. On average, up to hundred objects are observed per observing night. For more details see Pavlović et al. (2012).

The other observational project is a study of eclipsing close binary systems, which are very important for determination of some fundamental parameters. The photometric observations are recently obtained with the 60 cm Vidojevica telescope using the BESSEL filter set. Together with the observations, modeling of the light curves of close binary stars is an essential part of this study and is carried out within this project. These models are based on Roche geometry and incorporate a number of orbital and physical parameters of binaries. People involved in this project are: Dr. G. Djurašević, Dr. I. Vince, Dr. O. Vince, M. Jurković, A. Cseki and O. Latković.

The third project is the astrometric one. As known, GAIA started its mission in November 2013. One of the tasks is to construct a celestial reference frame (CRF) as a dense optical QSOs-based one. The plan is to observe about 500000 ERS (extragalactic radio sources). It will be important to align the GAIA and VLBI frames, and it requires QSOs that are bright at optical wavelength (QSOs with a compact radio/optical core and without complex structures). Due to this requirement, it is necessary to monitor some QSOs in the optical domain, and check the data (especially the position stability and structures). It means the astrometry in line with morphology and photometry. As a result, the optical telescopes are important to observe QSOs, which is useful for the mentioned ICRF-GCRF link (see papers Taris et al (2013) and Damljanović et al (2013) for more details). People who are involved in this project from our group (Dr. G. Damljanović. and Dr. O. Vince) do observations of QSO fields with both 60 cm Vidojevica telescope and several telescopes at the Rozhen Observatory in Bulgaria.

Acknowledgements. This research has been supported by the Ministry of Education, Science, and Technological Development of the Republic of Serbia (Projects No. 176011, Dynamics and Kinematics of Celestial Bodies and Systems, No. 176021, Visible and Invisible Matter in Nearby Galaxies: Theory and Observations, and No. 176004, Stellar Physics).

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