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WEBT Project and observations at the 60-cm ASV telescope

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At the Astronomical Observatory (AOB, Belgrade, Serbia), the observations of blazars by using the 60-cm telescope at Astronomical Station Vidojevica (ASV) were started at the beginning of 2013. During that year, we established a cooperation with the Astronomical Observatory of Torino (Osservatorio Astrofisico di Torino) as an international center for the Whole Earth Blazar Telescope (WEBT) program. Some time after that, we initialized the cooperation with colleagues from Bulgaria and Austria in the WEBT project, and used few Bulgarian telescopes (at the Belogradchik AO and Rozhen Observatory) and the 1.5-m Leopold-Figl one of University of Vienna (Austria). As result, about 20 objects were observed until the end of 2015 (in BVRI filters). Here, we present some of our WEBT observations and results.

Keywords: AGN objects, quasars, blazars

1 Introduction

In the host galaxy, it is a supermassive black hole which accretes the surrounding material. As a result, it forms an accretion disc and a relativistic jet; over the last years, that model is widely accepted. The blazars are a subclass of galaxies with active galactic nuclei (AGN), and with a relativistic jet pointing towards us. Through that jet the blazars release an immense energy, and because of it we can observe these objects at very large distances from us at all frequencies. The time-scales are from hours to years. At the Astronomical Observatory (AOB, Belgrade, Serbia), we have been observing these objects at the optical domain using the 60-cm instrument at Astronomical Station Vidojevica (ASV, Serbia) and a few other telescopes (in Bulgaria and Austria) from the beginning of 2013. Unlike normal galaxies, the blazars are dominated by non-thermal emission and the flux variation could be high-amplitude.

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In the R filter, the variation could be more than 1 magnitude, and our standard error is mostly on the level of 0.01 magnitude. So, our results (B, V, R and I magnitudes of the mentioned objects) are good for the investigation of these sources.

It is more than 50 years since the discovery of the first quasars (Schmidt 1963), but these objects are still mysterious in the Universe. To collect the necessary data (with more than 100 telescopes) and study blazars, the Whole Earth Blazar Telescope (WEBT), as an international project (Villata et al. 2007), was created in 1997. The WEBT started the new project GLAST-AGILE Support Program (GASP) in 2007, with gamma-ray data using the satellites GLAST (now called Fermi) and AGILE (Raitteri et al. 2011). Also, the polarimetric measurements in optical and radio domains and spectroscopic measurements were done. Here, we present our optical observations of WEBT objects, including some results and published papers.

2 Instruments

The installation of the 60-cm telescope at our new ASV site (of AOB) was in 2010. A few years after that, we started a cooperation with the Astronomical Observatory of Torino (Osservatorio Astrofisico di Torino), center for the international WEBT

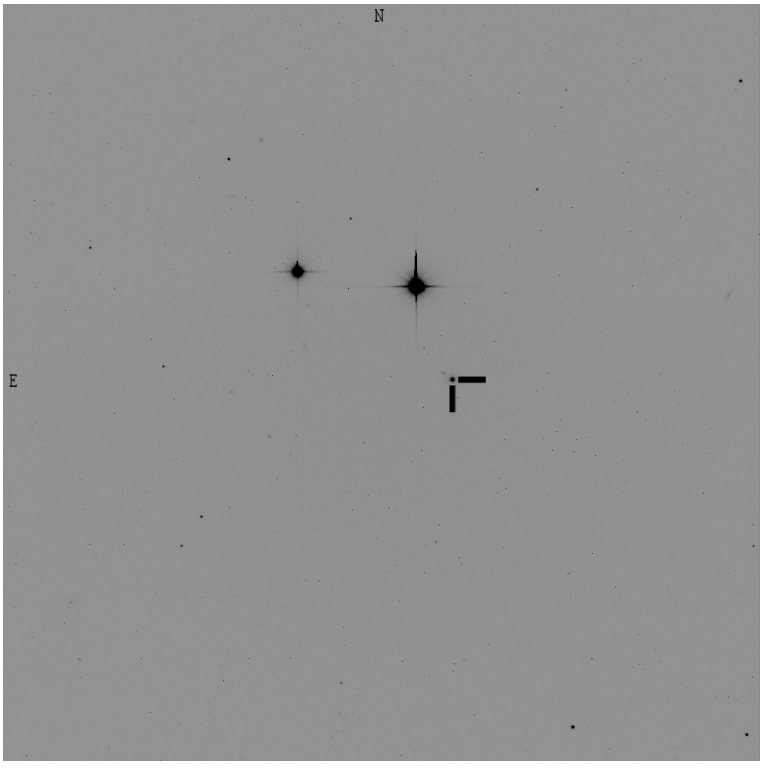


Figure 1 The Mrk 421 (L 1101+384) using the 60-cm ASV.

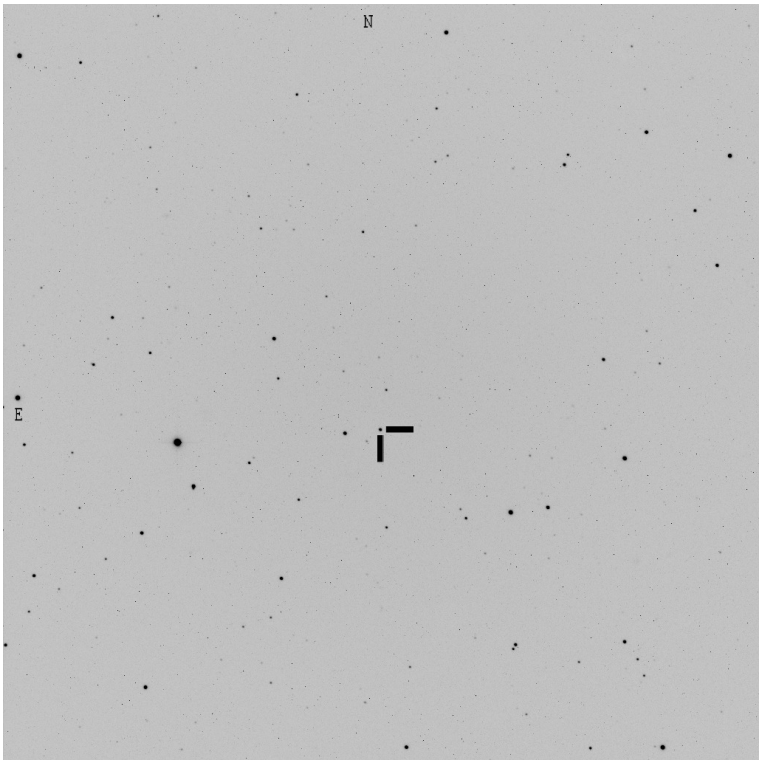


Figure 2 The object Q 1553+113 using the 60-cm ASV.

collaboration, and at the beginning of 2013 we did the astronomical observations of WEBT objects. First of all, it was the campaign for the Mrk 421 (L 1101+384, see Fig. 1) in April, then the campaign for the Q 1553+113 (see Fig. 2) in April–June, etc. On the other hand, during 2013 we established the Serbian–Bulgarian mini-network telescopes (there are 6 instruments with the 1.4-m ASV one) for Gaia-FUN-TO, and it was useful for the WEBT, too. During these years the reconstruction of the 1.5-m telescope was finished at the Leopold-Figl Observatorium für Astrophysics – LFOA (Vienna Observatory, Universität Wien), and via cooperation with Dr. Werner W. Zeilinger we used that instrument (at the end of 2013) for a few WEBT and other objects. Information about used instruments is in Table 1.

We observed WEBT objects in B,V,R and I bands (usually three CCD images per filter). About 20 WEBT objects (Vince and Damljanović 2014) were observed until now using a Johnson/Bessel filter set.

3 Results

For our observations of the WEBT objects, mostly the 60-cm ASV telescope is in operation. In collaboration with Bulgarian colleagues (in line with the bilateral joint research project "Observations of ICRF radio-sources visible in the optical domain"

Table 1 Main information of the telescopes.

Site, type, D[cm]/F[cm]	Longitude, λ (°), latitude, φ (°), altitude, h (m)	CCD camera, pixels, scale ($''$), pixel size (μm), FoV ($'$)
ASV (AOB), Cassegrain, 60/600	21.5E, 43.1N, 1150	Apogee Alta U42 2048×2048, 0.465 13.5×13.5, 15.9×15.9
Rozhen (NAO BAS), Ritchey-Crétien, 200/1600	24.7E, 41.7N, 1730	VersArray 1300B 1340×1300, 0.261 20×20, 5.6×5.6
Rozhen (NAO BAS), Cassegrain, 60/750	24.7E, 41.7N, 1759	FLI PL09000 3056×3056, 0.335 12×12, 16.8×16.8
Rozhen (NAO BAS), Schmidt-camera 50/70, $F = 172$	24.7E, 41.7N, 1759	FLI PL16803 4096×4096, 1.08 9×9, 73.7×73.7
Belogradchik AO, Cassegrain, 60/750	22.7E, 43.6N, 650	FLI PL09000 3056×3056, 0.335 12×12, 16.8×16.8
LFOA, R.C., $D = 152$	15.9E, 48.8N, 880	SBIG ST-10 XME 2184×1472, 0.15 6.8×6.8, 5.6×3.8

(head, Dr. G. Damljanović) and in accordance with the Serbian–Bulgarian mini-network telescopes), five Bulgarian telescopes (at two sites, the Rozhen Observatory and Belogradchik AO) are used: the 2-m Rozhen (National Astronomical Observatory – NAO, Bulgarian Academy of Sciences – BAS), 60-cm Rozhen, Rozhen 50/70-cm Schmidt-camera, and 60-cm Belogradchik AO one. Also, the 1.5-m telescope of the LFOA (Austria) is useful for the mentioned objects. About the CCD cameras and other information, see Table 1.

In Table 1, information in the first column is as follows: site, telescope and D[cm]/F[cm]. In the second column, the geographic coordinates (longitude λ, latitude φ) and altitude h of the site are presented. The FoV is field of view (in the third column). As an example, the 2-m Rozhen telescope (as the largest in Table 1) is shown in Fig. 3.

We are doing the photometry calculations in line with steps presented at the WEBT site (http://www.to.astro.it/blazars/webt). Usually, the standard bias, dark and flat-fielded corrections were done (also, hot/bad pixels were removed). The comparison stars were taken from the WEBT site. The calculated BVRI magnitudes, as the average value with standard error (of 3 CCD images per filter), were sent to the WEBT center (Torino Observatory). Here, it is possible to see the CCD image of the Mrk 421 or L 1101+384 (in Fig. 1 it is raw data with $Exp. = 15^s$ in R filter, binning $= 2 \times 2$, April 15^{th} 2013, CCD Apogee Alta U42, observer – O. Vince), and image of the Q 1553+113 (in Fig. 2, raw data with $Exp. = 60^s$ in R band, binning $= 2 \times 2$,



Figure 3 The 2-m Rozhen telescope (Bulgaria).

same date, CCD and observer); the 60-cm ASV was used. Some of our photometric results of the object 1101+384 are presented in Table 2. The standard error is on the level of 0.01 magnitude, and it means that our results are good.

We send our photometric results (of WEBT objects) to the Torino center, and a few papers about these objects have been published (Bhatta et al. 2015, Carnerero at al. 2015, Furniss et al. 2015, Raiteri et al. 2015, Vince and Damljanović 2014).

Table 2 Photometric results of 1101+384 for December 14 and 15, 2015.

Filter	JD	Magnitude with st. dev.
		December 14, 2015
B	2457371.46801	13.592 (0.023)
V	2457371.46888	13.137 (0.009)
R	2457371.46974	12.845 (0.023)
I	2457371.47060	12.368 (0.007)
		December 15, 2015
B	2457372.45585	13.571 (0.012)
V	2457372.45671	13.076 (0.009)
R	2457372.45757	12.782 (0.007)
I	2457372.45846	12.305 (0.005)

4 Conclusions

Here, we present our efforts in investigation of blazars. The instruments and equipments are described. There are about 100 instruments in line with the WEBT program, and the standard errors of our magnitudes (of BVRI bands) are in accordance

with the other results (of other instruments). During the period 2013–2015, we have observed about 20 objects in the WEBT list, and participated intensively in several WEBT campaigns. Also, we established collaboration with many experienced researchers in this field.

In May 2016, the new 1.4-m telescope was installed at the ASV site (in the frame of the Belissima project), and until now few WEBT objects were observed with success. So, we expect more data of that instrument (and other mentioned telescopes), soon.

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