Serb. Astron. J. № 188 (2014), 67 - 74
DOI: 10.2298/SAJ1488067V UDC 520.82 : 524.74–48–823
Professional paper

# RESEARCH OF BLAZARS AT THE ASTRONOMICAL OBSERVATORY OF BELGRADE

**O. Vince and G. Damljanović**

*Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia*
E–mail: *ovince@aob.rs*

(Received: March 19, 2014; Accepted: May 14, 2014)

**SUMMARY: At the beginning of 2013, we have a team of scientists at the Astronomical Observatory of Belgrade, focusing on observations and research of blazars. At the same time, we established a cooperation with the Astronomical Observatory of Torino (Osservatorio Astrofisico di Torino), center for the Whole Earth Blazar Telescope (WEBT) international collaboration. In this paper, we describe the WEBT project, present our equipment as well as some preliminary results. We also point to some issues that we have encountered during the one year experience and found important from the observational point of view.**

**Key words. BL Lacertae objects: general – techniques: photometric – miscellaneous**

## 1. INTRODUCTION

It is now widely accepted that blazars are subclass of galaxies with active galactic nuclei (AGN) having a relativistic jet closely pointing towards us. In the center of the host galaxy, there is a supermassive black hole which accretes the surrounding material and forms an accretion disc and a relativistic jet. Immense energy is released through the jet which makes possible to observe blazars at very large distances from us. Unlike normal galaxies, blazars are dominated by the non-thermal emission and they show high-amplitude flux variation at all frequencies from radio to high energy gamma-ray and on different time-scales from hours to years. Even 50 years after the discovery of the first quasar (Schmidt 1963), a huge effort is made to understand these mysterious object in the Universe. With that goal, a large international projects and multi-wavelength observing campaigns are organized.

The Whole Earth Blazar Telescope (WEBT) is an international project created in 1997 with aim to study blazars (e.g. Vilatta et al. 2007). Until 2009, the WEBT organized 24 observing campaigns, which included more than one hundred telescopes. 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 (now called Fermi) and AGILE (e.g. Raitteri et al. 2011). Generally, GASP's task is to provide a long-term optical-to-radio monitoring of selected blazars during the operation of two satellites. Beside the long-term monitoring, GASP organizes observing campaigns for some objects, though there are also campaigns for blazars not included into the list, like for blazar PG 1553+113 organized in April 2013. Most of campaigns were/are organized in conjunction with high-energy ground-based telescopes (MAGIC, VERITAS etc.), Gamma and X ray space instruments (INTEGRAL, RXTE, Chandra etc.), infrared space telescopes (Spitzer) and radio telescopes (VLA, VLBA etc.). In addition to photometric observations also polarimetric in optical and radio domains, and spectroscopic measurements are performed.

Optical observations are a very important part of the multi-frequency study of blazars. Small and moderate size telescopes, which are relatively cheap today and easy to maintain, can be used for observations of these objects. On the other hand, the impact of the results is high in the study of these puzzling objects. With this in mind, our group at the Astronomical Observatory of Belgrade (AOB) joined the WEBT project in 2013 with our 60cm aperture telescope at the Astronomical Station Vidojevica (ASV) run by AOB. This paper gives details about our team, instruments and presents some of preliminary results.

Section 2 describes our scientific team and collaborators. Section 3 focuses on the target list provided by the WEBT. We summarize our observational results and give short notes on issues we have experienced so far. Photometric measurements of these objects are not so simple since we are trying to measure AGN fluxes, which are embedded in elliptical host galaxies and compare them to stellar fluxes. In Section 4, we tackle some of the issues that we experienced in one year of observation and measurements. In the last Section 5, we draw our conclusions.

## 2. RESOURCES

For observations of the WEBT objects, we mostly use our 60 cm ASV telescope. It is located on the mountain of Vidojevica in southern Serbia. The site has a relatively good seeing (median 1.2 arcsec) and a number of usable clear nights (Jovanović et al. 2012). As a part of the BELISSIMA[1] project, which is supported by the EU Seventh Framework Programme, we expect to purchase a new 1.4 m telescope in a near future.

The 60 cm ASV telescope is Cassegrain type with 60 cm and 20 cm primary and secondary mirrors, respectively. Main characteristics of the telescope are given in Vince and Jurković (2012). Several CCD cameras were provided for data acquisition, but the most frequently used one is the ALTA Apogee U42, which is thoroughly tested by Vince (2012). We have both, the Stromgren and Johnson/Bessel filter sets, but only the later has been used for observations so far. For spectroscopic measurements, we provided one portable fiber-feed spectrograph which is examined for its characteristics by Vince and Lalović (2005). Attached to the 60 cm ASV telescope, the spectrograph has a relatively small light power and, consequently, it has never been used for any systematical observation. Vince et al. (2014) describe all observational programs performed since the installation of the 60 cm ASV telescope in 2010.

Beside the 60 cm ASV telescope, we use data from several Bulgarian telescopes, as well as one Austrian telescope, for observations of the WEBT objects: 60 cm Cassegrain and 2m RCC telescopes at Rozhen National Astronomical Observatory operated by the Institute of Astronomy, Bulgarian Academy of Science[2] and 1.5m telescope at the Leopold Figl Observatorium fuer Astrophysik of Vienna University (LFOA).

Our observational team is modest in number. We have two active members (G. Damljanovic and O. Vince) and 8 close collaborators who are ready to observe WEBT-GASP targets during their observational time or contribute in other way to our efforts (M. Stojanović, Z. Cvetković, R. Pavlović, G. Latev, S. Boeva, R. Batchev, J. Nuspl, H. Tibor, W. Zeilinger).

Observations are calibrated (bias, dark, flat etc.) and photometry is performed in either IRAF[3] (O. Vince) or Maxim DL (G. Damljanović) softwares. Basically, they provide identical final results. In the IRAF, the whole procedure is automatized in the CL scripting language.

## 3. WEBT TARGET LIST

List of the WEBT-GASP blazars is given in Table 1. Their names are given in the first and second column. The third column contains redshifts of the objects. The fourth column indicates if the blazar is the BL Lac or FSRQ class. Column five indicates the number of nights that blazars were observed until now. Each object is observed at least three times during a night in each filter. Column six indicates the telescopes that were used for observations; Vi60 and Ro60 stand for the 60 cm telescopes at ASV and NAO BAS Rozhen[4], Ro2 is for the 2m Rozhen telescope, and LFOA is for the 1.5m telescope at the LFOA. Beside blazars from the list, we performed observations for campaign on 1553+113 organized in April 2013.

Table 1 is a good overview of our activities in one year. So far, we have observed more then half of objects from the list and were very active in three WEBT campaigns. We believe that this score will improve in the close future since we plan to involve more colleagues into the project. In addition, we expect to install one more telescope at the ASV, which should increase the number of effective observations during clear nights.

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

[2] *http://www.nao-rozhen.org/telescopes/fr_en.htm.*

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

[4] National Astronomical Observatory of Bulgarian Academy of Science

**Table 1.** List of the WEBT-GASP blazars.

| IAU Name | Name | z | Type | Number [day] | Telescope |
|---|---|---|---|---|---|
| 0219+428 | 3C 66A | 0.44 | BL Lac | 1 | Vi60 |
| 0235+164 | AO 0235+16 | 0.94 | BL Lac | 2 | Ro2,LFOA |
| 0420-014 | PKS 0420-01 | 0.914 | FSRQ | / | / |
| 0528+134 | PKS 0528+134 | 2.06 | FSRQ | / | / |
| 0716+714 | S5 0716+71 | 0.3 | BL Lac | 5 | Vi60,Ro2,LFOA |
| 0735+178 | PKS 0735+17 | 0.424 | BL Lac | 2 | Vi60 |
| 0827+243 | OJ 248 | 0.939 | FSRQ | 2 | Vi60,LFOA |
| 0829+046 | OJ 49 | 0.174 | BL Lac | 1 | Vi60 |
| 0836+710 | 4C 71.07 | 2.172 | FSRQ | 1 | Vi60 |
| 0851+202 | OJ 287 | 0.306 | BL Lac | 1 | Vi60 |
| 0954+658 | S4 0954+65 | 0.368 | BL Lac | 2 | Vi60,LFOA |
| 1101+384 | Mrk 421 | 0.030021 | BL Lac | 7 | Vi60,Ro60,Ro2 |
| 1156+295 | 4C 29.45 | 0.729 | FSRQ | / | / |
| 1219+285 | ON 231 | 0.102 | BL Lac | 1 | Vi60 |
| 1226+023 | 3C 273 | 0.158339 | FSRQ | / | / |
| 1253-055 | 3C 279 | 0.5362 | FSRQ | / | / |
| 1510-089 | PKS 1510-08 | 0.36 | FSRQ | / | / |
| 1611+343 | DA 406 | 1.401 | FSRQ | 1 | Vi60 |
| 1633+382 | 4C 38.41 | 1.81357 | FSRQ | / | / |
| 1641+399 | 3C 345 | 0.5928 | FSRQ | / | / |
| 1652+398 | Mrk 501 | 0.033663 | BL Lac | 4 | Vi60 |
| 1739+522 | 4C 51.37 | 1.375 | FSRQ | / | / |
| 1807+698 | 3C 371 | 0.051 | BL Lac | 1 | Vi60 |
| 2155-304 | PKS 2155-304 | 0.116 | BL Lac | / | / |
| 2200+420 | BL Lacertae | 0.0686 | BL Lac | 1 | Vi60 |
| 2230+114 | CTA 102 | 1.037 | FSRQ | / | / |
| 2251+158 | 3C 454.3 | 0.859 | FSRQ | 1 | Vi60 |
| 2344+514 | 1ES 2344+514 | 0.044 | BL Lac | 2 | Vi60 |

WEBT-GASP provides a finding chart for all targets in the list[5]. Blazars are clearly marked there, as well as the comparison stars that are recommended for differential photometry. We give a few notes here on some of the issues that we have encountered during one year of observations/measurements of these blazars using the given set of comparison stars.

**Saturated stars close to blazar.** An extreme case is the long-time studied Mrk 421, with two close, relatively bright stars in the field (6th magnitude 51UMa and 12th magnitude BD+39 2414B). In practice, it is impossible to gain sufficient signal-to-noise ratio for the blazar without saturating these two stars. All comparison stars given in the WEBT-GASP finding chart, together with the Mrk 421 itself, are very close to these two stars and the scattered light has certainly an impact onto their photometry. In addition, there is a relatively bright galaxy very close to Mrk 421 with a similar effect. Pace et al. (2013) found the comparison star marked by number 3 in the finding chart to be problematic, that is, they found large difference in their magnitudes relative to the previously published values. Therefore, they do not recommend to use this star for photometry.

Another, similar but less extreme, examples of this type are blazars 0235+164, 0420-014, 1611+343.

**Lack of standard photometry for some comparison stars.** A good example is 0528+134 where I band photometry is not provided for a given comparison stars, or 0827+243 where only V and R band are provided for 5 comparison stars. We note however that WEBT insists only on R band measurements and always highlights what the other filter-bands are needed for their campaigns. The WEBT-GASP list could be updated with standard photometry data published in some recent papers. For example, Pace et al. (2013) provide I band photometry for stars 1, 2, 3 marked in the finding chart for Mrk421.

**Large magnitude difference between blazar and comparison stars in the field.** Good examples are: 0235+164, 0420-014, and 0528+134. One potential problem is purely technical - it is difficult to keep both, the target and the comparisons, in the linear range of the CCD response if the magnitude differences are large. Another problem is statistical and important when light curves of blazars are analyzed and tested. Howell et al. (1988) note that one should select comparison stars that are not just non-variable but also closely match the target's

[5] http://www.to.astro.it/blazars/webt/

magnitude. If this is not so, the measured dispersion of the target-comparison light curve will be different from that of the control-comparison light curve, just due to random noise sources (photon statistics, sky, read out noise), even in the absence of any intrinsic variations in the target. This is important when microvariability of a blazar is tested.

**Comparison stars are at large distances from a blazar**. Generally, this has two drawbacks. First, some standards fall out from small field of view of telescopes with large focal ratio. We often experience this while working on the 2m RCC telescope at NAO Rozhen. Second, the flat-fielding errors tend to be larger at larger distances from the object of interest.

**Overlapping.** In some cases, due to bad seeing conditions, a blazar overlaps with some close object (e.g. 0735+178, 1219+285, 2344+514). It is difficult to pull out appropriate photometry with the aperture technic and the PSF photometry seems to be more appropriate.

**Color differences**. WEBT does not insist on correction for the color term, so one should count with possible errors. For example, light curves of non-variable comparison stars might show systematic positive or negative trend if their colors are much different. In our experience, this trend can be as large as 0.1 mag in about 4 hours of observation.

## 4. PHOTOMETRY

Beside the standard reduction procedure (correction for bias, dark and flat images), WEBT requires differential instrumental magnitudes of a blazar relative to comparison stars provided in the WEBT-GASP finding charts. No additional corrections such as corrections for Galactic extinction or host galaxy light are required from observers. These and similar corrections must be performed in a uniform way since different methods may provide drastically different results. Some of these questions will be tackled below.

The most common way of doing differential photometry is to define a circular aperture around the object and an annulus around the aperture for the background correction. WEBT has few requirements on the aperture setup. Most of the objects are far enough to act as a point-like sources, so the optimal aperture radius is the one providing the highest signal-to-noise ratio. Howell (1989) determined the optimal extraction aperture to be about FWHM and to depend slightly on the brightness of an object in the CCD. However, there are a few close blazars in the WEBT list (see Table 1) with large projected sizes, where this measurement strategy is not the best choice. Cellone et al. (2000) showed that such photometric apertures can lead to spurious flux variations due to seeing variability with time. The effect is stronger for a brighter host galaxy and smaller aperture radius in use (see their Figs. 8 and 9). In absolute terms, this effect is not very strong, but becomes important when we want to study low amplitude variations (few tenths of magnitudes), that is, microvariability of blazars.

There are four close blazars in the WEBT-GASP list where the aperture radii are precisely defined. These are: Mrk 421, Mrk 501 and 1ES 2344+514 for which the recommended aperture radius is 7.5 arcsecs and BL Lacertae for which the aperture radius is 8 arcsecs (Raiteri, private communication). There is one more close blazar, 3C 371, for which there is no exact definition of the aperture radius given. Their finding charts are given in Fig. 1.

For campaigns on the BL Lacertae blazar, beside the 8 arcsecs aperture radius, the inner and outer radii of the annulus are also defined (10 and 16 arcsec, respectively). With this fixed aperture/annulus setup, one can estimate the flux that originate from the host galaxy, which is about 60% for this blazar (e.g. Raiteri et al. 2009). Indeed, using 4.8 arcsecs for the blazar's effective radius (see Scarpa et al. 2000), the basic integration over the de Vaucouleur's profile gives 64% of the host galaxy contribution in the 8 arcsecs aperture. We can also estimate that we have already subtracted about 4% of the host galaxy light by subtracting the background extracted from the annulus. Thus, our aperture includes about 60% of the host galaxy light. Adopting, for example, 15.55 mag in R band for this blazar (Scarpa et al. 2000) and 0.9 for the total Galactic extinction in the R band toward this object (from NED[6]), we can calculate that one has to subtract 2.54 mJy from the de-reddened R-band flux to eliminate the host contamination.

It is interesting to note that different authors provide different values for the effective radius for the BL Lacertae blazar. For example, Nilsson et al. (2003) calculate 8.2 arcsecs despite the fact that they have also used de Vaucouleur's profile in the calculation procedure. Nilsson et al. (2007) allowed a slope of the brightness profile to be a free parameter in the fitting procedure and obtained 10.4 arcsecs for the effective radius. Taking 8.2 arcsecs for the effective radius instead of 4.8 arcsecs used above, changes the galaxy light contribution in the 8 arcsecs aperture from 60% to 45%.

Fig. 2 illustrates the fraction of the host galaxy light in the 8 arcsecs aperture radius as function of the effective radius of a galaxy. It is calculated for the aperture/annulus setup defined for the BL Lacertae blazar (8, 10, 16 arcsecs radii). Two curves are shown - the dashed line shows the fraction of the host galaxy light without correction for the subtracted light from the annulus, while the solid line shows the same after correction. We can conclude that: 1) the host galaxy light contribution in 8 arcsecs aperture radius is large for compact elliptical galaxies such as the host galaxy of the BL Lacertae blazar and 2) the curve is very steep for such galaxies. The latter fact should remind us that slightly different values for the effective radius can give quite different results. Moreover, it is known that elliptical

[6]http://ned.ipac.caltech.edu

galaxies tend to be bluer in their outer regions than in their cores, so one should be aware of the possible errors that are introduced if the effective radius measured in one filter band is uncritically applied to the analysis in other filter bands.

With different approach, Nilsson et al. (2007) calculated the contaminating fluxes from the host galaxy plus nearby companions for about 20 blazars. All close blazars from Fig. 1 are in their list too. The fluxes are calculated for a range of aperture radii and seeing FWHMs. It is interesting to note that for the BL Lacertae blazar observed with 8 arcsecs aperture radius they calculate about 1.4 mJy for the whole range of the seeing FWHM. This is quite different from 2.54 mJy calculated by Raiteri et al. (2009). The reason for such discrepancy might be due to different approaches of two authors, but partly it is because they take different values for the R band magnitude for the host galaxy. We also note that we couldn't find any instruction (exact aperture/annulus setup) in Nilsson et al. (2007) on using their values from the tables to correct measurements for the host galaxy light contamination.

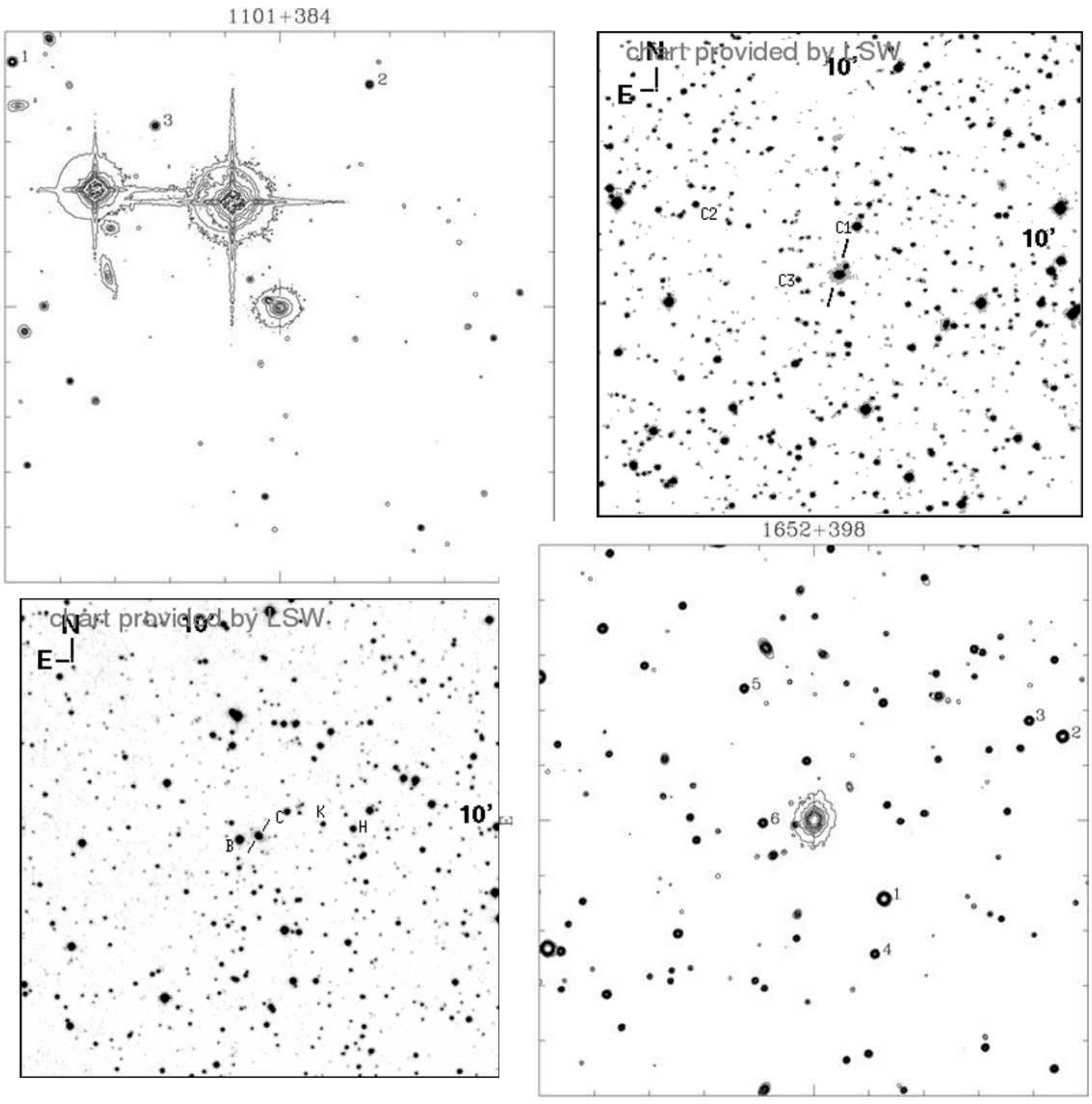


**Fig. 1.** *Finding charts for four closest blazars in the WEBT-GASP list; Mrk 421 in the upper left, Mrk 501 in the lower right, BL Lacertae in the lower left, and 1ES 2344+514 in the upper right panel. Finding charts are taken from the WEBT official page http://www.to.astro.it/blazars/webt/.*

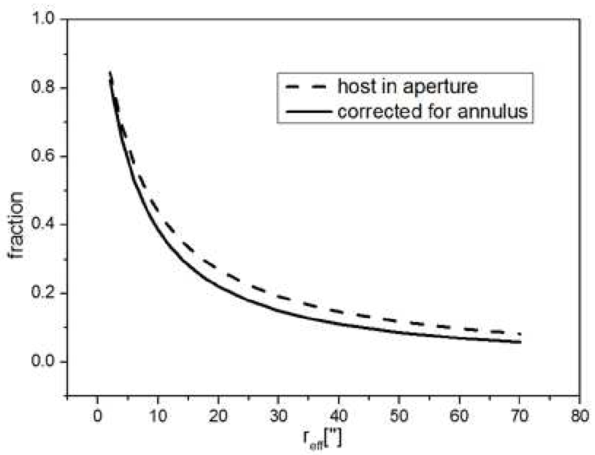


**Fig. 2.** *Fraction of the host galaxy light in the 8 arcsecs aperture radius. Dashed line corresponds to the fraction of the galaxy host light without correction for the light in the annulus. Solid line corresponds to the same but with the correction.*

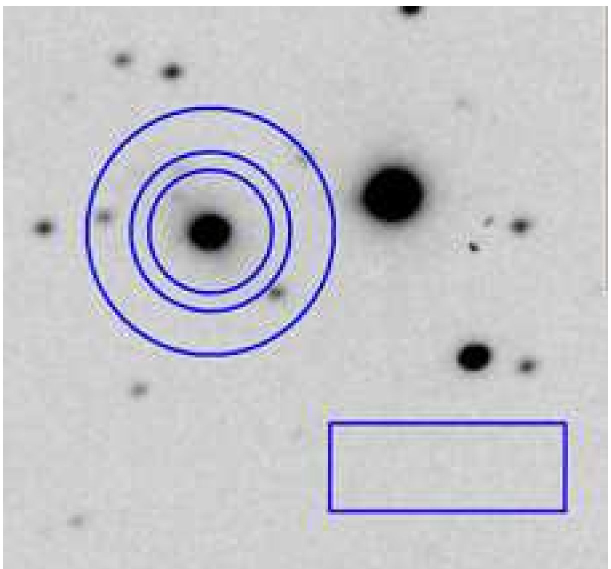

**Fig. 3.** *The aperture/annulus setup for the BL Lacertae blazar .*

Fig. 3 shows the BL Lacertae blazar and the aperture/annulus setup mentioned above. The annulus includes two relatively bright stars[7]. In order to estimate their contribution to the photometry, we define a box-like aperture and use it for an independent background estimation. The box is defined to be close to blazar but free of any source contamination. The analysis is done on the BVRI stacked images taken in July 2013 with the 60 cm telescope at the ASV. Comparison of the measurements obtained with the annulus and box-like region shows that fluxes in the BVRI bands change by about 7, 4, 4, and 6 percent due to the presence of these two stars in the annulus. This corresponds to 0.08, 0.04, 0.04, and 0.06 magnitude differences in the BVRI bands, respectively.

For other close blazars mentioned above, there is no exact setup definition given by the WEBT for their inner and outer radii. One way to deal with the galaxy host light contribution to annulus is to set it far from the sources where the galaxy host contribution drops below certain level (Raiteri, private communication). In the case of BL Lacertae for instance, the contribution of the host galaxy to annulus drops below one percent by increasing the gap between the aperture and annulus for 8 arcsecs. However, this is not always possible especially in a crowded field where we risk to include bright stars in the annulus. Another way is to set an annulus at arbitrary radii and deal with systematic errors.

We have already mentioned the correction for Galactic extinction in the example of the BL Lacertae blazar. It is important whenever we want to compare models with our observations. There are three different possibilities for the correction: 1) using a global mean extinction curve (e.g. Seaton 1979, Savage and Mathis 1979), 2) using an R-dependent curve (e.g. Cardelli et al. 1989), and 3) using a sightline-specific curve. The first one is the least attractive of the three cases, but is the most frequently used. The R-dependent curve is an analytical representation of the extinction which depends on one parameter ($R_V$). Diffuse interstellar matter is described by small values ($R_V \approx 3$), while dense regions by larger values ($R_V \approx 5$). However, at any given $R_V$, most observed extinctions deviate from the mean R-dependent curve by more than the observational error. This is especially true for short wavelengths ($\lambda$ <0.14 $\mu$m). The mean extinction curve of Seaton (1979) and Savage and Matis (1979) can be described by the R-dependent curve with $R_V \approx$ 3.1. Thus, one should be aware of the fact, that the correction for the extinction in dense interstellar regions with the mean extinction curve will introduce large systematic errors.

## 5. CONCLUSIONS

In this paper, we present our effort in research of blazars. Our team and equipment that we use for observations are described. We point to some observational issues that we met during one year of observation. Our discussion on these issues can be summarized as follows:

[7]In this particular setup, there is also a faint star close to the annulus border, but its contribution is much smaller. Beside, due to its closeness to the annulus limit, its contribution depends on the aperture centering.

(1) There are some cases in the WEBT-GASP target list when close bright stars are close to a blazar and/or comparison stars. One should be aware of possible contamination by the scattered light of these stars and adequately deal with it in the photometric measurements.
(2) Many comparison stars in the WEBT-GASP finding charts do not have standard photometric measurements. For long-term monitoring, WEBT insist only on the R band measurements and always highlights what other filters are needed for campaigns. Nevertheless, one may find newly determined values for many standards in the WEBT-GASP finding charts in the literature.
(3) Large magnitude difference between a blazar and comparison stars, might be a serious problem. There are several examples in the WEBT-GASP target list of this kind. Most of them have plenty of nearby stars with comparable magnitudes to the blazar's one, and it might be very useful to determine their standard photometry.
(4) If comparison stars are at large distances from a blazar might also be a problem. We find useful to determine standard photometry for closer stars in the field as well.
(5) Overlapping of some blazars with close stars in bad seeing conditions are also problematic for standard aperture photometry measurements.
(6) Correction for the color term in the extinction is not required from WEBT observers. However, one should certainly be familiar with errors introduced in this way.
(7) In the case of large size host galaxy, one has to deal with the host galaxy light contribution and correct measurements for it. We mentioned two ways for doing it - one described by Raiteri et al. (2009), the other described ny Nilsson et al. (2007). Raiteri's way is much simpler and easy to reproduce, while Nilsson's method is more complex.

During just one year, we have observed more then half of the objects in the WEBT list and participated intensively in three WEBT campaigns.

In the future, we plan to improve our effort on blazar research by involving more people, by installation of a new telescope, and by extension of our collaboration with experienced researchers in this field. As part of the WEBT, we plan to continue to contribute by observations.

*Acknowledgements* – The authors gratefully acknowledge the observing grant support from the Institute of Astronomy and Rozhen National Astronomical Observatory, Bulgarian Academy of Science. 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".

REFERENCES

Abdo, A. A. et al.: 2011, *Astrophys. J.*, **736**, 131.
Bottcher et al.: 2009, *Astrophys. J.*, **703**, 1168.
Cardelli, J. A., Clayton, G. C., Mathis, J. S.: 1989, *Astrophys. J.*, **345**, 245.
Cellone, S. A., Romero, G. E., Combi, J. A.: 2000, *Astron. J.*, **119**, 1534.
Corbett, E. A. et al.: 1996, *Mon. Not. R. Astron. Soc.*, **281**, 737.
Howell, S. B., Mitchell, K. J., Warnock III, A.: 1988, *Astron. J.*, **95**, 247.
Howell, S. B.: 1989, *Publ. Astron. Soc. Pacific*, **101**, 616.
Jovanović, M., Stojanović, M., Martinović, N., Bogosavljević, M., Smolić, I. and Acković, B.: 2012, *Publ. Astron. Obs. Belgrade*, **91**, 83.
Nilsson, K., Pursimo, T., Heidt, J., Takalo, L. O., Sillanpaa, A. and Brinkmann, W.: 2003, *Astron. Astrophys.*, **400**, 95.
Nilsson, K., Pasanen, M., Takalo, L. O., Lindfors, E., Berdyugin, A., Ciprini, S. and Pforr, J.: 2007, *Astron. Astrophys.*, **475**, 199.
Pace, C. J., Pearson, R. L., Moody, J. W., Joner, M. D. and Little, B.: 2013, arXiv:1303.1380v1.
Paczynski, B.: 1996, *Annu. Rev. Astron. Astrophys.*, **34**, 419.
Padovani, P., and Giommi, P.,: 1995, *Astrophys. J.*, **444**, 567.
Raiteri, C. M. et al.: 2009, *Astron. Astrophys.*, **507**, 769.
Raiteri, C. M. et al.: 2011, *Astron. Astrophys.*, **534**, 87.
Sambruna, R., M., , Maraschi, L., and Urry, C. M.,: 1996, *Astrophys. J.*, **463**, 444.
Savage, B. D., Mathis, J. S.: 1979, *Annu. Rev. Astron. Astrophys.*, **17**, 73.
Seaton, M. J.: 1979, *Mon. Not. R. Astron. Soc.*, **187**, 73.
Scarpa, R., Urry, C. M., Falomo, R., Pesce, J. E., Treves, A.: 2000, *Astrophys. J.*, **532**, 740.
Schmidt, M.: 1963, *Nature*, **197**, 1040.
Vermeulen, R. C., Ogle, P. M., Tran, H. D. et al.: 1995, *Astrophys. J.*, **452**, 5.
Villata, M., Raiteri, C. M., Sillanpaa, A., and Takalo, L. O.: 1998, *Mon. Not. R. Astron. Soc.*, **293**, 13.
Villata, M. and Raiteri, C. M.: 1999, *Astron. Astrophys.*, **347**, 30.
Villata, M. et al.: 2007, *Astron. Astrophys.*, **464**, 5.
Wiita, P. J.: 1996, *ASP Conf. Series*, **110**, 42.
Vince, O., Jurković, M.: 2012, *Publ. Astron. Obs. Belgrade*, **91**, 77.
Vince, O.: 2012, *Serb. Astron. J.*, **185**, 65.
Vince, I. and Lalović, A: 2005, *Serb. Astron. J.*, **171**, 55.
Vince, O., Cvetković, Z, Pavlović, R., Damljanović, G. and Djurašević, G.: 2014, *Contrib. Astron. Obs. Skalnate Pleso*, in press.
Wagner, S. J. and Witzel, A.: 1995, *Annu. Rev. Astron. Astrophys.*, **33**, 163.

# ПРОУЧАВАЊЕ БЛАЗАРА У АСТРОНОМСКОЈ ОПСЕРВАТОРИЈИ У БЕОГРАДУ

**O. Vince and G Damljanović**

*Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia*
E–mail: *ovince@aob.rs*

УДК 520.82 : 524.74–48–823
*Стручни чланак*

Почетком 2013. године, формирали смо тим научника у Астрономској опсерваторији у Београду који се бави проучавањем блазара. Успоставили смо сарадњу са Астрономском опсерваторијом у Торину (Италија), који је центар за Whole Earth Blazar Telescope (WEBT) интернационални пројекат. У овом раду, кратко описујемо WEBT пројекат, инструменте са којима радимо на посматрању блазара као и приказујемо неке прелиминарне резултате. Такође указујемо на неке потенцијалне посматрачке проблеме на које смо наишли у току једногодишњег посматрања блазара.