Optical Variability of Selected Blazars

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Abstract. As a part of the Whole Earth Blazar Telescope (WEBT) and GLAST-AGILE Support Program (GASP) campaign 24 objects were observed in UBVRI for 13 nights during the period of 21 June 2017 – 11 March 2019 using the 50/70 cm Schmidt Telescope at NAO Rozhen. Over the observational campaign some of the sources showed variability of the optical emission with high and low states. For the objects S5 0716+714 and 4C 29.45 (Ton 599) R-band variability amplitude of 1.7 and 2.4 mag is registered. Correlation between color index (B-V), (V-R) and R-band magnitude for OJ287 and Mrk421 is observed.

Keywords: AGN, astronomy, observations, photometry

1. INTRODUCTION

Blazars are a subclass of Active Galactic Nuclei (AGN) identified with non-thermal emission across the entire electromagnetic spectrum, strong linear polarization and large amplitude variability in all wavelengths and on diverse timescales, ranging from minutes up to years. Their emission originates from relativistic jets aligned near the line of sight, according to the AGN unified model (Urry & Padovani, 1995). In their spectrum there are well-defined two energy peaks extending from radio up to gamma-rays (Mukherjee et al, 1997). The low energy peak, from radio to ultraviolet (UV)/soft X-rays, is due to synchrotron emission from the relativistic electrons of the jet (Ulrich, Maraschi & Urry, 1997). The high energy peak, from hard X-rays to gamma-rays, is due to inverse Compton scattering (Sikora & Madejski 2001; Böttcher, 2002).

In the last two decades the study of AGN is improved by organizing multiwavelength observations – from gamma rays to radio waves. In 1997 the Whole Earth Blazar Telescope (WEBT) was born as an international network of multi-wavelength telescopes used for monitoring of blazars. The purpose of the simultaneously observation in the whole Spectral energy distribution (SED) is to explore and study the intense and very rapid variability of the blazars. The WEBT data is important for the understanding of the blazar nature mechanisms. The beamed synchrotron emission from the jet hides the spectral line features when the source is in outburst state. In 2006-2007 WEBT performed a monitoring of the quasar-type blazar 3C 454.3 in the radio, near-infrared, optical, X-ray and UV rays (Raiteri et al, 2007). The source was in faint state and this allowed the exploration of specialities of the spectrum. The study of the collected data showed a little bump in the optical band of 3C 454.3 due to the contribution of Fe II and Mg II. The major feature is the observed rise of the SED in the UV, suggesting the existence of a "big blue bump", which was already recognized in other quasar-type blazars, due to thermal emission from the accretion disk. This results are a proof of the Unified AGN Model (Urry & Padovani, 1995).

The WEBT organized continuous monitoring of a list of selected gamma-ray-loud blazars - the GLAST-AGILE Support Program (GASP) which started in 2007. In the list of GASP are 28 objects – gamma-ray loud blazars.

Bulgaria is a part of the collaboration of WEBT for more than 15 years with observations from Rozhen NAO. In this article we represent UBVRI-band observational data for the period 2017-2019 of 24 objects from the list of GASP. Twenty month R-band light curves for the whole targets are obtained and variability with various amplitude is registered. For the OJ287 and Mrk421 variations between color and magnitude is seen. The object S5 0716+714 is observed in outburst in March 2018.

2. OBSERVATIONS

As a part of the Whole Earth Blazar Telescope (WEBT) and GLAST-AGILE Support Program (GASP) campaign we observed 24 objects in UBVRI-bands for 13 nights during 21 June 2017 – 11 March 2019 using the 50/70 cm Schmidt Telescope at NAO Rozhen. The telescope is equipped with CCD detector model FLI PL 16803 with chip size 4096 x 4096 pixels. On Fig. 1 is shown the

amount of the observed blazars in the period 2017 – 2019.

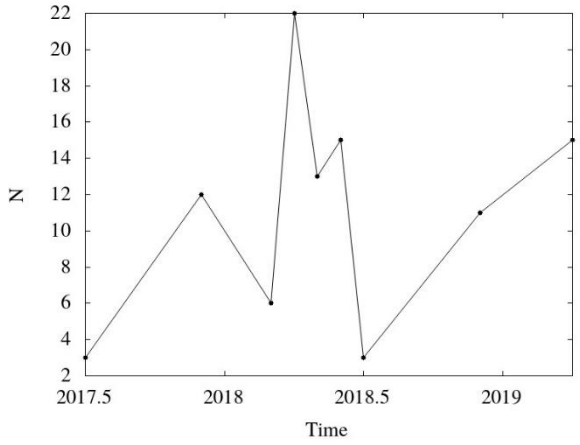

Fig. 1 X-axis is the month of observation and y-axis is the number of the observed blazars.

3. DATA REDUCTION

The raw photometric data reduction and corrections were processed by standard methods using Image Reduction and Analysis Facility (IRAF[1]). We performed dark substraction, flat-fielding and alignment of individual frames for each object. After the pre-processing procedures we performed photometry using the aperture photometric technique with the Dominion Astrophysical Observatory Photometry (Daophot) software from IRAF. For the observed blazars we used comparison stars given in the GASP target list. The registered R-band variability amplitude is up to 2.43 mag in the case of 4C 29. The typical magnitude error is less than 0.05 mag. In Table 1 are shown the minimum and maximum magnitude, obtained in the R-band observational data. On Figs. 2, 3, 4 and 5 are shown the light curves (LCs) of the objects 4C29, Mrk421, OJ287 and S5 0716, respectively.

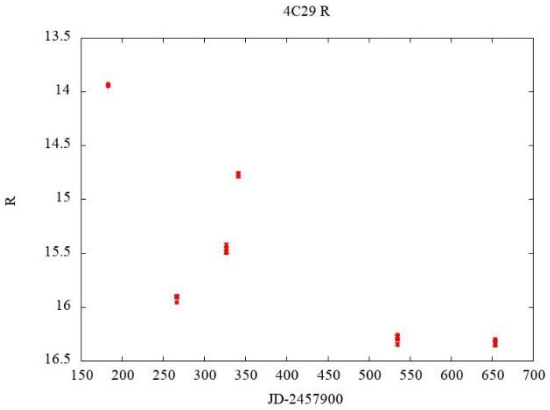

Fig. 2 LC for 4C29. X-axis is JD (2459000+) and y-axis is the R-band magnitude.

TABLE 1. Minimum and maximum magnitude of the observed objects in R-band.

Object	max R	min R
3C66	14.59	14.70
3C273	12.78	12.88
3C279	14.10	15.49
3C345	17.40	17.54
3C371	14.14	14.16
3C454	15.29	15.31
4C29	13.92	16.35
4C38	15.91	15.95
4C71	16.47	16.62
AO0235	18.05	18.22
BL Lac	12.81	13.41
CTA102	15.30	15.66
DA406	17.70	17.86
Mrk421	12.52	12.97
OJ49	15.83	16.10
OJ248	16.90	17.05
OJ287	14.51	15.43
ON321	14.11	15.22
PG1553	12.76	13.43
PKS0420	17.07	18.32
PKS0735	16.25	17.02
PKS1510	15.86	16.17
S4 0954	14.25	15.62
S5 0716	12.33	14.08

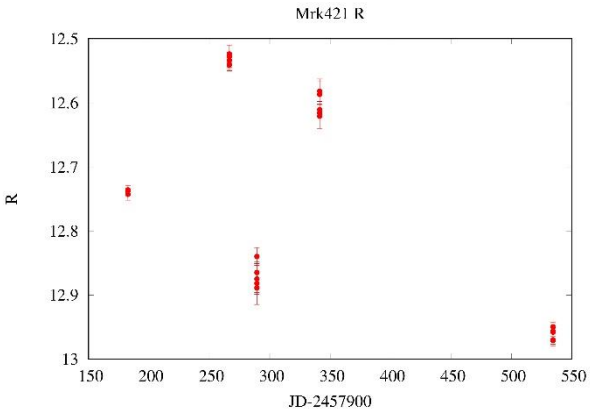

Fig. 3 LC for Mrk421. X-axis is JD (2457900+) and y-axis is the R-band magnitude.

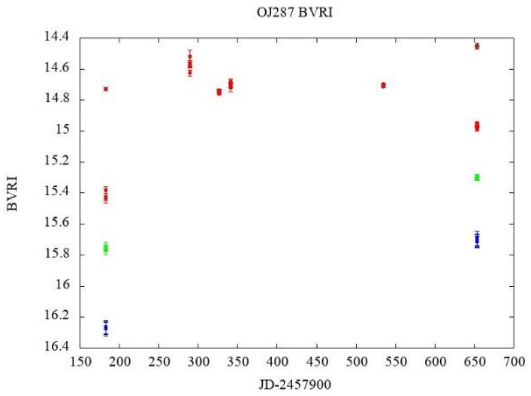

Fig. 4 LC of OJ287 in BVRI filters. X-axis is JD (2457900+) and y-axis is the magnitude. The blue points are for B-band, green is for V, red is for R, brown is for I-band magnitude.

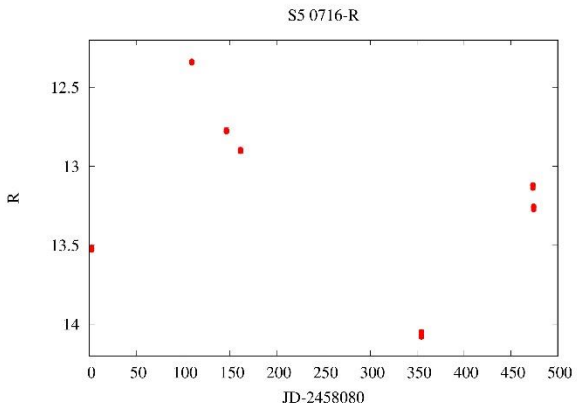

Fig. 5 LC of S5 0716 in R-band. X-axis is JD (2458080+) and y-axis is the magnitude.

4. DISCUSSION

The source 4C 29.45 also known as Ton 599 has shown short and long term optical variability in previous studies. Here we register variation of 2.43 mag in R-band from 13.92 mag to 16.35 mag. This is comparable with the obtained variability of 2.57 mag by Fan et al. (2006).

The BL Lac object S5 0716 has a large amplitude variability in the optical flux and is one of the most active blazars. We observed this source in outburst state with maximum R = 12.33 mag on 11 March 2018. It was historically brightest with R = 11.68 – 11.71 mag on January 2015 (Chandra et al, 2015; Bachev & Strigachev, 2015). This object shows signs of quasi-periodic oscillation and many searches are made in order to prove it (Bhatta et al, 2016).

We found a correlation between the color and the V magnitude of two blazars. The correlation is $Y = kV + c$, where k is the fitted value for the slope of the curve and c is the constant. We define the positive correlation as a positive slope which means that the object is bluer when it brightens or redder when it faints. A negative slope is when the source tends to be redder when it brightens. For the source Mrk 421 the correlation shown in Fig.6 with positive slope is in agreement with the obtained in Gaur et al. (2012).

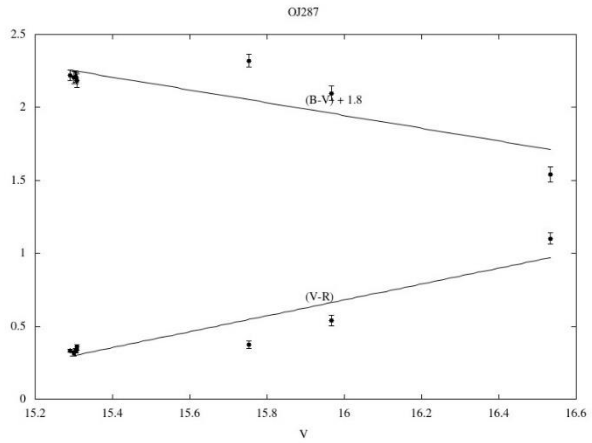

Fig. 6 Color-magnitude plot of Mrk421. X axis is the V magnitude and Y axis is the color index. The values of k and c for (V-R) are 0.13 and -1.4, respectively; for (B-V) k=0.07 and c=-0.49.

The correlation between color and V magnitude for OJ287 is shown on Fig. 7. The positive slope of the color index (V-R) means that when it brightens it tends to be bluer. The slope of the color index (B-V) shows the same behavior of the source. The correlation is in agreement with the obtained correlation in Gaur et al. (2012). This blazar is one of the most interesting extragalactic objects be-cause of the 12 year outburst cycle (Valtonen & Ciprini, 2012) and the rapid variation of the optical polarization (Bozhilov et al, 2014).

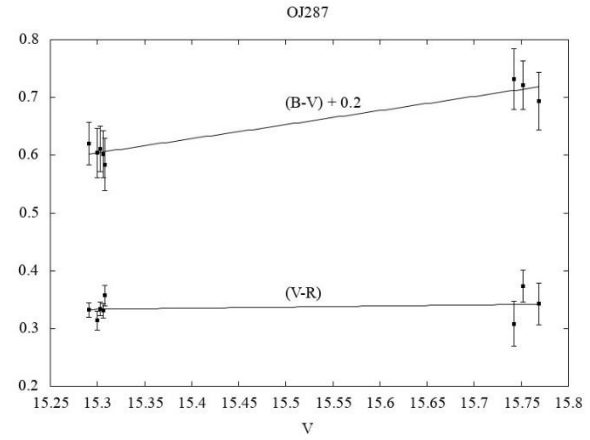

Fig. 7 Color-magnitude plot of OJ287. X-axis is the V magnitude and y-axis is color. The values of k and c are: for (V-R) $k = 0.01$, $c = 0.05$; for (B-V) $k = 0.24$, $c = -3.12$.

5. CONCLUSIONS

We have obtained observations of 24 blazars in UBVRI bands. The objects 4C29 and S5 0716 show large R-band variability amplitude of 2.4 and 1.7 mag, respectively. S5 0716 is observed in outburst state with R = 12.33 mag. Correlation between color (B-V), (V-R) and V magnitude is found for OJ287 and Mrk421. The obtained relation for Mrk421 and OJ287 – bluer when it brightens and redder when it faints is in good agreement with previous data.

The results shown in this study are preliminary. The data will be used for upcoming studies of the nature of blazars and their variability amplitude.

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