Short term optical variability of blazars: first results from joint international collaborations

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Abstract. We present some preliminary results from optical monitoring of blazars as a part of joint WEBT campaigns and Indo-Bulgarian collaboration.
Key words: galaxies: BL Lacertae objects: general

Кратко-временна оптическа променливост на блазари: първи резултати от международни сътрудничества

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Представени са първоначални резултати от оптически мониторинг на блазари като част от международната кампания WEBT и Българо-Индийско сътрудничество.

Introduction

Blazars (the name comes from the archetype BL Lac) are among the most amazing objects of the Active Galactic Nuclei (AGN) class. They are unique in many respects, one of which is their fast and violent optical variability. Significant magnitude changes within a night have been observed repeatedly, and variations of $\sim$0.1 mag per hour are not unusual for many of them. It is not yet firmly established what the nature of the mechanisms that cause these abrupt changes is. As it is often assumed, the central engine of blazars is a super-massive black hole with a mass of order of 100 million solar masses, so the processes responsible for these sudden and sharp luminosity changes should be of extreme power.

On the other hand, other types of AGN also contain black holes of similar masses but do not show such a rapid variability. Nowadays, it is widely accepted that the unique properties of blazars, including their fast variability, are due to a relativistic jet, pointed almost directly toward the observer Fig. 1. processes in relativistic plasma, accelerated along the jet to a speed, close to the speed of light. Thus, the study of these processes by monitoring of the optical continuum changes may be of great importance for the blazar astrophysics, high-energy physics, astroparticle physics, plasma physics, etc., especially taking into account, that the physical mechanisms responsible for launching and collimating such relativistic jets remain largely unknown.

Actually, blazars are natural particle accelerators reaching energies that vastly exceed those, achieved by any accelerator on Earth. In this paper we present examples of short-term variability of blazars, observed as a part of joint international collaborations, including WEBT[1] and GASP[2] campaigns and an Indo-Bulgarian collaboration. We would also like to emphasize the importance of a wide international collaboration to study blazar variability on different time scales.

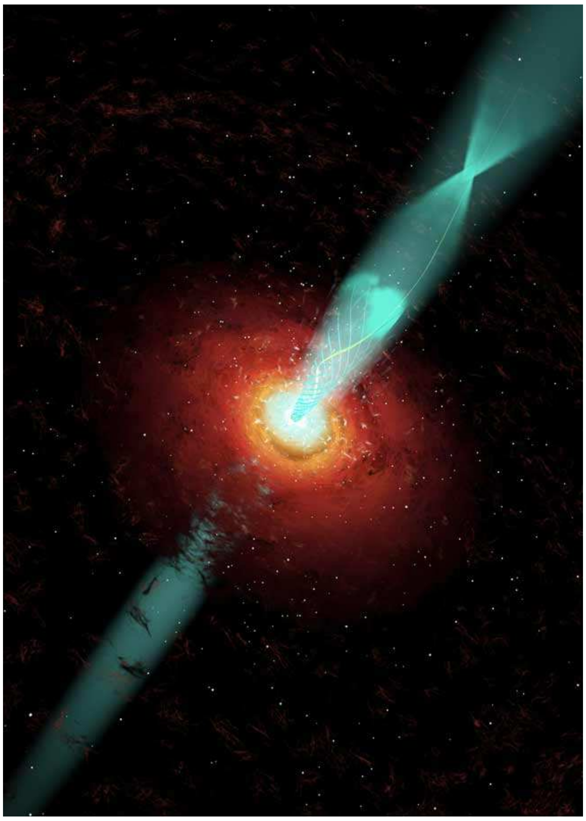

Fig. 1. Schematic representation of a blazar. An accretion disk around a supermassive black hole is able to launch and collimate a relativistic jet under certain conditions. The details of this process remain largely unknown. If the jet is pointed almost directly toward the observer, the object manifests itself as a blazar.

[1] WEBT is an abbreviation of the Whole Earth Blazar Telescope and is a world-wide network of blazar monitoring telescopes of different sizes and types, http://www.to.astro.it/blazars/webt/

[2] GASP (*Glast-Agile* Support Program) is a structure within WEBT to provide radio-optical data for gamma-ray blazars, monitored from space with *Agile* and *Fermi* (formerly *Glast*) satellites

The need of a wide international collaboration

Blazars are often among the highest priority targets in the observational astronomy, both ground-based and from space. To build a dense light curve and so to study the short-term variability, one typically needs to combine observations from many different observatories located all over the world. That is why we joined the efforts of the WEBT society for monitoring of some targets of common interest. Some preliminary results for a few objects (3C 454.3, 3C 279, 3C 66A, AO 0235+164, S5 0716+71 and OJ 287) have been already published [Böttcher et al. 2007, Böttcher et al. 2009, Raiteri et al. 2007, Raiteri et al. 2008a, Raiteri et al. 2008b, Raiteri et al. 2008c, Larionov et al. 2008, Strigachev et al. 2007, Villata et al. 2009]. Recently, a bilateral collaboration between astronomers from Bulgaria and India has been initiated and the first results from this joint project have been prepared for publication [Rani et al. 2010].

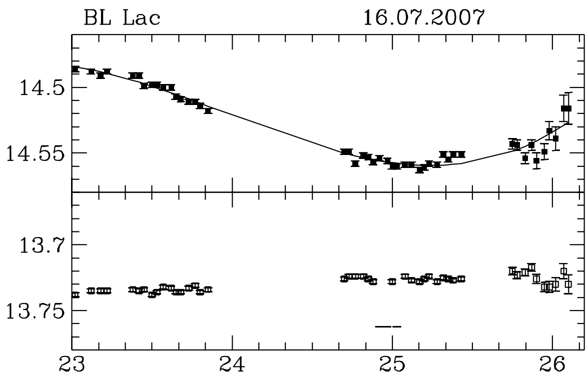

Fig. 2. R-band light curve of BL Lac. The upper box is the blazar, the lower one – a check star to control the accuracy of the differential photometry. The photometric errors are indicated as error bars. A polynomial is fitted to the blazar light curve to guide the eye. The abscissa shows UT in hours for the corresponding date, indicated at the top of the figure

As blazars emit within the entire range of electromagnetic spectrum (from radio to TeV-energy gamma rays), their study requires combining observations form different instruments, both ground- and space-based. Radio, infrared and optical observations are carried out using ground-based telescopes, while the higher energy range of the spectrum (ultra-violet, X-rays, and gamma rays) is monitored with space-based instruments like *Fermi-LAT, XMM-Newton, Swift, Agile, Integral, Egret,* etc. The ultra-high energy gamma rays are monitored with ground-based Cherenkov telescopes, like *MAGIC, HESS, VERITAS*, etc. Organizations like WEBT (GASP) often coordinate the entire monitoring campaign.

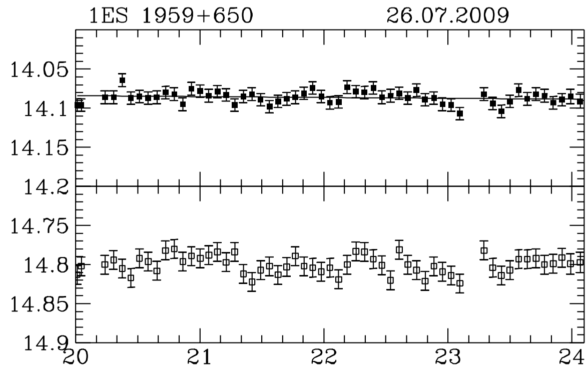

Fig. 3. The same as Fig. 1 for 1ES 1959+650

Observations and first results

Photometric observations of blazars reported here are performed at the observatories of the Institute of Astronomy, Bulgarian Academy of Sciences – the National Astronomical Observatory (NAO) Rozhen, and Astronomical Observatory Belogradchik (AOB). Three optical telescopes are used for the monitoring: 2-m RCC and 50/70-cm Schmidt telescopes at NAO Rozhen, and 60-cm Cassegrain telescope at AOB. All these telescopes are equipped with contemporary CCD detectors that allow high quality photometric performance. The filters in use are the broad-band UBVRI Johnson-Cousins.

In the Fig. 2–4 we show examples of light curves of blazar, monitored on different time scales. Fig. 2 presents the R-band variations of BL Lac, monitored for ∼3 hours on 16.07.2007 with the 2-m RCC telescope of NAO Rozhen [Bachev et al. 2010]. The object was monitored as a part of a WEBT campaign [Raiteri et al. 2009]. Variations of up to 0.1 mag are clearly seen. Fig. 3 shows the results of the monitoring of another blazar 1ES 1959+650, observed for ∼4 hours with the 60-cm telescope of AO Belogradchik during the night of 26.07.2009. In this case, however, no variability is detected (the magnitude trend is less than 0.001 mag/hour), indicating that not all blazars are violently variable all time. The last figure (Fig. 4) shows the multicolor variations on day-to-week scale of 3C 66A. The object was monitored with different instruments as a part of a Bulgarian-Indian joint project. One sees variations of up to 0.5 mag (more details in [Rani et al. 2010]). Multicolor (BVRI) monitoring allows study of color changes and may help to understand the physical mechanisms, causing the variability.

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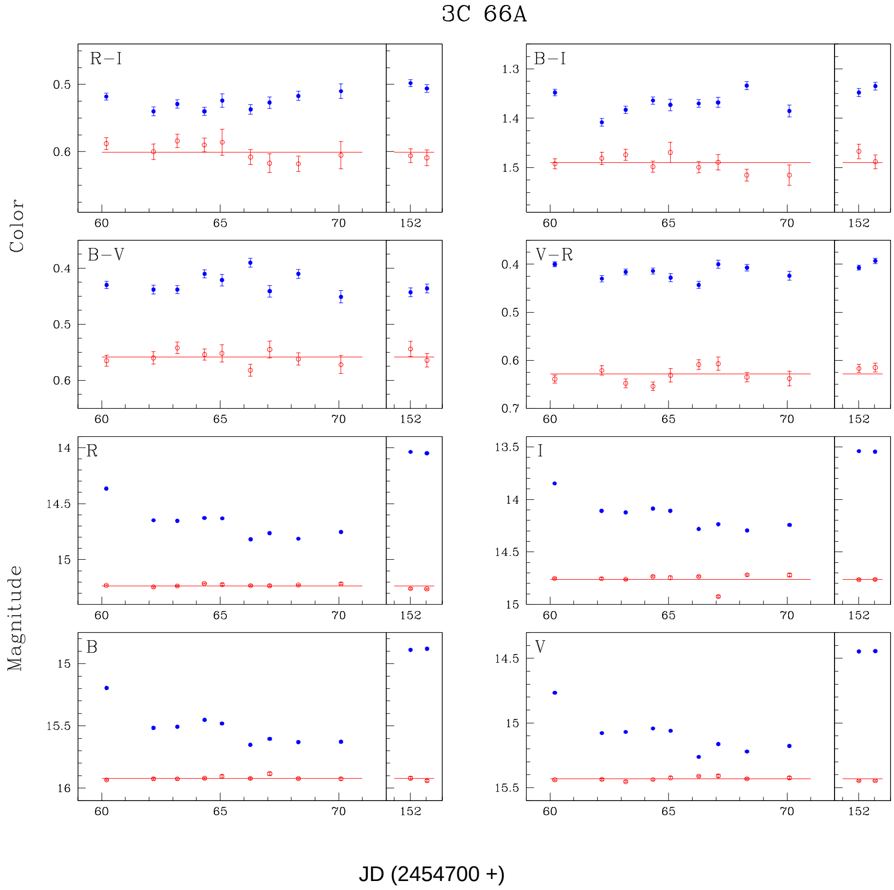

Fig. 4. Variability and color changes of 3C 66A, monitored Oct. 2008 – Jan. 2009. Although significantly variable during the monitoring, no significant color changes are seen for this object

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