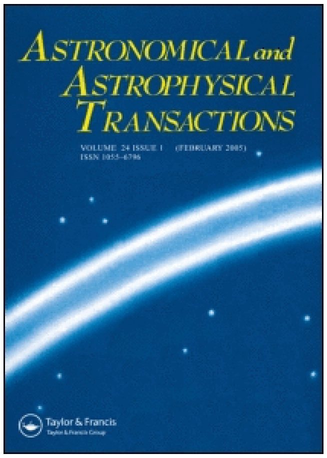

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BVRI CHARGE-COUPLED DEVICE PHOTOMETRY OF ACTIVE GALACTIC NUCLEI AT ABASTUMANI OBSERVATORY

O. M. KURTANIDZE[a,b,*], M. G. NIKOLASHVILI[c], O. P. ABULADZE[c], S. M. CHANTURJIA[c], B. KAPANADZE[c], G. N. KIMERIDZE[c] and L. A. SIGUA[c]

[a]Astrophysical Institute of Potsdam, An der Sternwarte 16, D-14482 Potsdam, Germany;
[b]Landessternwarte Heidelberg-Königstuhl, D-69117 Heidelberg, Germany;
[c]Abastumani Observatory, 383762 Abastumani, Georgia

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We give a brief summary of the ongoing Abastumani active galactic nuclei monitoring programme started in May 1997. More than 65 000 frames have been obtained during observations of about 50 target objects, among them X-ray, γ-ray and optical blazars, for more than 700 nights. All observations were made in the BVRI bands using an ST-6 charge-coupled device photometer attached to the Newtonian focus of a 70 cm meniscus telescope.
Image reductions have been performed using image reduction packages Daophot II. The light curves illustrating the activity of selected blazars in R band, namely 3C 66A and AO 0235 + 164, are presented.
Most objects under study show light variations in the optical band over one magnitude. The largest was observed for AO 0235 + 116, of magnitude 4.0 in the R band.

Keywords: Active galaxies; BL Lacertae; Quasars

1 INTRODUCTION

Among active galactic nuclei, blazars are objects most dominated by non-thermal continuum emission, which extends from radio to γ-rays, and whose properties are best explained by emitting plasma in relativistic motion towards the observer, closely aligned with the line of sight (Urry and Padovani, 1995). One of the distinguishing characteristics of the blazar which includes BL Lacertae-type objects, high-polarization quasars and optical, violently variable quasars is that their flux densities are highly variable at all wavelengths from radio to γ-rays. Therefore optical multiband monitoring together with other techniques gives unique clues into the size and structure of the radiating region. Variability time scales have been derived for many blazars from monitoring programmes which attain a time resolution of days to years (Wagner and Witzel, 1995). The best example of international cooperation is the multiwavelength study of selected blazars in the OJ-94 project carried out during the last decade (Takalo et al., 2000).

* Corresponding author. E-mail: okur@kheta.ge

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The observations by GGRO show that strongly variable and radio-loud quasars emit a significant fraction of their energy in the γ-ray band. Variability of the γ-ray flux on a time scale as short as 4 h has also been observed (Mattox et al., 1997). Unfortunately, existing multiwavelength data are not adequate yet to permit definite conclusions to be drawn about the nature of blazars because the optical coverage in previous campaigns has been much too sparse. Therefore, Mattox (2000) suggested that a coherent use of existing ground-based optical facilities will dramatically improve the quality of the optical data obtained during multiband blazar campaigns.

We started systematic multiband optical monitoring of blazars at Abastumani Observatory in May 1997. In late October 1997 we joined the Whole Earth Blazar Telescope (http://www.to.astro.it/blazars/webt). The aim of the programme is to study intraday (IDV) and intrahour (IHV) variability and long-term variability (LTV) of blazars and their correlations in the radio, X-ray and γ-ray bands.

2 OBSERVATIONS AND DATA REDUCTION

Abastumani Observatory is located in the southwestern part of Georgia at a latitude of 41°.8 and a longitude of 42°.8 on the top of Mount Kanobili at 1700 m above mean sea level. The weather and visibility are very good in Abastumani (150 nights per year, a third of which have a viewing of less than one arcsec). The mean values of the magnitudes of the night sky brightness are B = 22.0, V = 21.2, R = 20.6 and I = 19.8.

A blazar monitoring programme was started at Abastumani Observatory by Kurtanidze and Nikolashvili in May 1997 (Abuladze, Chanturjia, Kapanadize, Kurtanidze and Sigua joined in early 2002) and is carried out with a Peltier-cooled ST-6 charge-coupled device (CCD) imaging camera attached to the Newtonian focus of a 70 cm meniscus telescope (1/3). The pointing accuracy of the meniscus telescope is 1–2 and it is good enough to locate a target object inside the full frame field of view of $14.9' \times 10.7'$. The ST-6 imaging camera uses a TC241 CCD chip ($375\,\mu\text{m} \times 242\,\mu\text{m}$, $23\,\mu\text{m} \times 27\,\mu\text{m}$) with a maximum quantum efficiency of 0.7 at 675 nm. The read-out digitizing downloading time of a full frame is 37 s.

All observations are performed using combined filters of glasses which match the standard B, V (Johnson) and R_C, I_C (Cousins) bands well. Reference sequences in the blazar fields are calibrated using the Landolt (1992) equatorial standard stars. On photometric nights, at least one equatorial field is observed with different exposures. Because the scales of the CCD and resolution of the meniscus telescope are equal to $2.3' \times 2.7'$ per pixel and $1.5'$ respectively, the images are strongly undersampled; therefore to improve sampling it is necessary to defocus frames slightly. Unfortunately, a high dark current limits the exposure time to 900 s.

The primary data analysis software systems used are IRAF, MIDAS and STARLINK installed on a Pentium personal computer (RH Linux 6.2; 250 MHz MMX; 64 Mbytes; 20.4 Gbits). The image reduction was done using Daophot II. The highest differential photometric accuracy reached is 0.007 (rms) magnitude in the R band (180 s) in the field of OJ 287 (comparison star 10 of magnitude 14.34 and star 11 of magnitude 14.65).

3 RESULTS

A list of target objects was compiled using three catalogues (Véron-Cetty et al., 1993; Padovani and Giommi, 1996; Perlman et al., 1996). In the period from May 1997 to

February 2002, during more than 700 observation nights, more than 65 000 frames were obtained. In Table I the list of the target objects together with the number of observation nights and frames obtained in all the BVRI bands in excess of 20 are given. The last column shows the number of frames obtained to study the intraday variability (IDV) and intrahour variability (IHV) of selected blazars.

Among the most frequently observed objects are BL Lacertae S5 0716 + 714, AO 0235 + 164 and MKR 421 (Kurtanidze and Nikolashvili, 2002a).

Several campaigns have been conducted during the great outburst and post-outburst era of BL Lacertae, 3C 279, MRK 241, AO 0235 + 164, 4C 29.45, S4 0954 + 65 and ON 231. Some of the results have been published (Kurtanidze and Nikolashvili, 2001b,c,d,e; Massaro et al., 1999; Nikolashvili and Kurtanidze, 1999a,b; Tosti et al., 1999a,b; Fan et al., 2001; Hartmann et al., 2001a,b,c; Kurtanidze, 2001a; Nesci et al., 2001; Raiteri et al., 2001) while others are submitted for publication (Kurtanidze and Nikolashvili, 2002a,b; Nikolashvili and Kurtanidze, 2002a,b).

TABLE I List of Target Objects.

		Observations				
Name	Number of nights	N_B	N_V	N_R	N_I	$N_{IDV,Nights}$
S2 0109 + 22	78	77	77	98	53	402, 4
3C 66A	87	79	81	104	55	943, 9
AO 0235 + 164	79	51	81	123	52	1 102, 15
1ES0323 + 022	27	21	27	37	24	
PKS 0422 + 004	45	41	48	58	29	330, 12
1ES0502 + 675	38	28	35	46	27	
S5 0716 + 714	154	191	183	237	183	6 246, 160
OI 09.4	30	26	29	33	26	
ES0806 + 524	34	34	36	38	32	
0J 049	23	21	21	23	21	
OJ 287	55	71	73	86	62	190, 5
S4 0954 + 658	69	45	69	82	68	249, 14
1ES1011 + 496	26	25	25	28	21	
1ES1028 + 511	32	29	30	31	27	
MKR 421	55	82	82	89	79	1 906, 47
4C 29.45	51	59	58	71	59	150, 5
ON 231, W Com	82	79	78	103	80	
3C 273	30	33	31	35	33	
3C 279	48	47	46	54	43	127, 4
OQ 530	41	37	39	48	36	
OQ 240	46	42	36	46	37	648, 11
23	15	22	21	22		
4C 38.41	20	12	16	26	17	
3C 345	69	61	67	79	66	208, 8
MRK 501	74	75	86	92	66	167, 5
1722 + 119	44	43	40	51	35	
I ZW 187	69	65	65	80	76	
S4 1749	57	49	51	66	43	
1803 + 784	51	50	45	72	36	
3C 371	70	72	66	55	88	
1ES1959 + 650	80	69	67	92	65	1 219, 33
S5 2007 + 777	21	20	18	26	4	
OW 154.9	47	33	44	34	32	
BL Lacertae	317	283	299	457	253	16 227, 239
CTA 102	24	24	24	35	24	
3C 454.3	43	37	41	63	44	59, 3
S2 2254 + 074	53	50	56	69	38	
1ES2344 + 514	57	32	52	71	51	312, 7

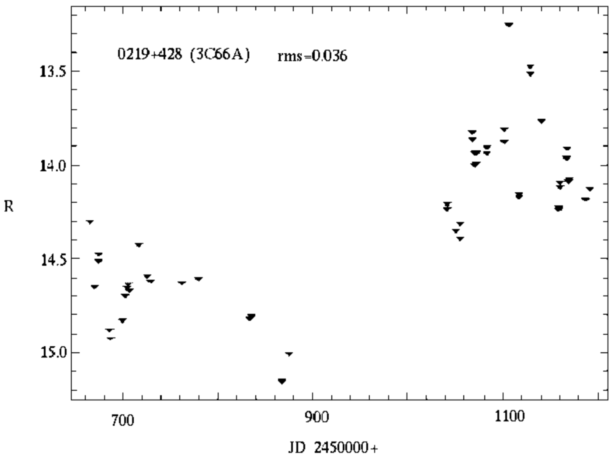

FIGURE 1 The LTV light curve of 3C 66A during September 1997–January 1999.

Most objects under study show light variations of over one magnitude in the optical band. The largest was observed for AO 0235 + 164 and equals to 4.0 in the R band. The light curves illustrating the activity of selected blazars in the R band, namely 3C 66A and AO 0235 + 164, are presented in Figures 1 and 2.

A few faint variable stars (B ≈ 16.0–17.0) with amplitude magnitude of 0.3–0.4 and periods of 3–5 h were also identified. One surprising example is the comparison star 5 (Villata et al., 1999) in the field of TeV BL Lacertae object ES 1959 + 650 showing a light variation of magnitude over 0.3.

4 CONCLUSION

All objects under study show significant variability on all time scales. The largest was observed for AO 0235 + 16, a magnitude of 4.0 in the R band. X-ray blazars show variability of magnitudes 0.2–1.0 in the R band. Consequently, their IDV is very small, 0.05.

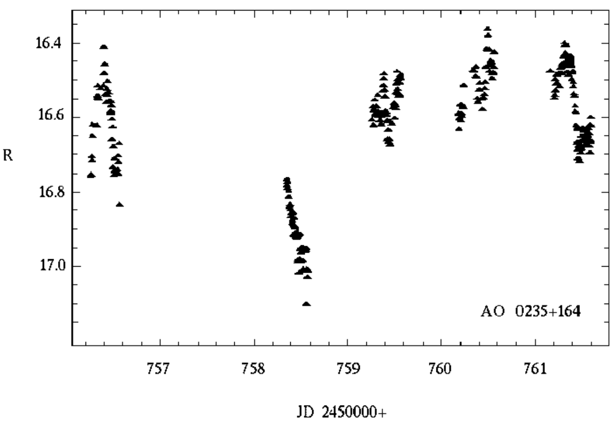

FIGURE 2 The IDV and IHV light curves of AO 0235 + 16 during 1–10 November 1997.

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