ASTRONOMY & ASTROPHYSICS
SUPPLEMENT SERIES

MARCH I **1998**, PAGE 315

Astron. Astrophys. Suppl. Ser. **128,** 315-324 (1998)

Variability in blazars*

Jia Guibin, Cen Xuefen, Ma Huiyu, and Jiancheng Wang

Yunnan Observatory, Academia Sinica, P.O. Box 110, Kunming, Yunnan, PR China

Received May 31, 1995, accepted June 19, 1997

Abstract. The results of both *BVRI* CCD photometric monitoring and fast photometry for 8 blazars and variable quasars are presented. There is intraday variability for 6 blazars and very short timescales (minutes to two hours) variability for 5 objects. Implications for relativistic beaming are briefly discussed.

Key words: BL Lacertae objects — quasars

1. Introduction

Blazars exhibit rapid variability in both luminosity and polarization at all wavebands (Angle & Stockman 1980). The optical variability of blazars is relevant to physical condition in the deep interiors of the objects and general constraints on the emission mechanism can be derived from the characteristics of variations (Wallinder et al. 1992). A program to investigate the optical variability in blazars, utilizing modern CCD detectors, has been undertaken by us since 1987. Preliminary results have been reported by Guibin et al. (1995). Now, the results of a fast photometry monitoring for 8 blazars, PKS 0422+004, PKS 0754+101, B2 1156+295, 3C 334, OT 081, PKS 2254+074, PHL 658 and PKS 2128 − 123, are presented. Variability on time scales significantly less than a day was observed for PKS 0422+004, PKS 0754+101, B2 1156+295, OT 081 and PKS 2254+074.

2. Observations

From 1987 November to the end of 1994, we monitored these objects and consecutive photometry at some colour was performed during a few nights for the objects PKS 0422+004, PKS 0754+101, B2 1156+295, OT 081, PKS 2254+074, PHL 658 and PKS 2128 − 123. The CCD attached to the 1-m RCC telescope at the Yunnan Observatory in China was a RCA 53612 (number 1) before 1993, and a TeK 512mc (number 2) since 1993, with 320 ×512 and 512 ×512 pixels of $30 \times 30\ \mu\mathrm{m}^2$ and $27 \times 27\ \mu\mathrm{m}^2$, respectively. The fields of view of the CCD system are $2.5' \times 4.1'$ for number 1 located at the Cassegrain focus (f/13.3) of the telescope and $5' \times 8.2'$ and $7.4' \times 7.4'$ respectively for number 1 and number 2 which were attached to a focal reducer since 1991. The comparison star sequences are taken from Smith et al. (1985) and Miller et al. (1983) for PKS 0754+101 and PKS 0422+004, from Angione(1971) for PKS 2128 − 123, 3C 334 and PHL 658, from Craine et al. (1975) for both OT 081 and 2254+074 and taken from Smith et al. (1985) for B2 1156+295. The comparison stars and the objects are in the same frame. The characteristics of the filters are the same as those of the Kitt Peak National Observatory (Schild 1983).

3. Data reduction

The method of data reduction had been detailed in the previous paper (Guibin et al. 1995). The comparison stars are intercalibrated. All observations are reduced by relative photometry against the comparison stars in the same frame and the weighted average of extinction values of the comparison stars is used to calibrated the object. The uncertainty of the final magnitude of the object contains the errors of measured magnitudes of the comparison stars and the object and the uncertainties of magnitudes beyond the atmosphere for the comparison stars. The results obtained for the objects are listed in Table 1. The weighted average of the magnitudes and colour indices, which are calculated by two subsequent observations of different colours each night are tabulated in Table 2.

4. Results

The results of the observations are now given for each object.

Send offprint requests to: Jia Guibin

* Table 1 is also available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

Table 1. Observation for 8 blazars

Date	JD (2400000+)	Mag	Error	Band
	PKS 0422 + 004			
11/17/87	47117.144	15.61	0.06	*B*
	47117.242	15.55	0.06	*B*
	47117.152	15.11	0.06	*V*
	47117.250	15.10	0.06	*V*
11/7/93	49299.170	15.11	0.04	*B*
	49299.200	14.94	0.04	*B*
	49299.225	14.66	0.03	*V*
	49299.228	14.67	0.03	*V*
	49299.231	14.72	0.03	*V*
	49299.236	14.74	0.03	*V*
	49299.240	14.72	0.03	*V*
	49299.243	14.70	0.03	*V*
	49299.247	14.70	0.03	*V*
	49299.250	14.72	0.03	*V*
	49299.256	14.72	0.03	*V*
	49299.259	14.73	0.03	*V*
	49299.262	14.73	0.03	*V*
	49299.276	14.67	0.03	*V*
	49299.282	14.66	0.03	*V*
	49299.285	14.64	0.03	*V*
12/4/93	49326.104	15.07	0.03	*V*
	49326.109	15.09	0.03	*V*
	49326.119	15.14	0.02	*V*
	49326.126	15.08	0.02	*V*
	49326.133	15.14	0.03	*V*
	49326.142	15.17	0.03	*V*
	49326.149	15.19	0.03	*V*
	49326.163	15.13	0.03	*V*
12/5/93	49327.117	15.89	0.04	*B*
	49327.122	15.90	0.04	*B*
	49327.133	15.56	0.03	*V*
	49327.141	15.59	0.03	*V*
	49327.149	15.61	0.03	*V*
	49327.160	15.49	0.03	*V*
	49327.167	15.44	0.03	*V*

Date	JD (2400000+)	Mag	Error	Band
12/5/93	49327.176	15.48	0.03	*V*
	49327.184	15.46	0.03	*V*
	49327.193	15.46	0.03	*V*
	49327.201	15.42	0.03	*V*
	49327.209	15.45	0.03	*V*
12/6/93	49328.094	15.31	0.03	*V*
	49328.134	15.31	0.03	*V*
1/6/94	49358.987	14.97	0.03	*V*
	49358.995	14.97	0.03	*V*
	49359.019	14.84	0.03	*V*
	49359.024	14.80	0.02	*V*
	49359.033	14.82	0.02	*V*
	49359.042	14.93	0.02	*V*
	49359.062	14.85	0.02	*V*
	49359.071	14.89	0.02	*V*
	49359.078	14.96	0.02	*V*
	49359.087	15.38	0.03	*B*
1/7/94	49359.966	15.03	0.02	*V*
	49360.001	15.05	0.03	*V*
	49360.011	14.98	0.03	*V*
	49360.022	14.93	0.02	*V*
	49360.029	14.92	0.02	*V*
	49360.043	14.83	0.02	*V*
	49360.056	14.83	0.02	*V*
	49360.067	14.74	0.02	*V*
	49360.077	14.78	0.02	*V*
	PKS 0754 + 101			
12/4/91	48595.288	16.28	0.06	*B*
	48595.341	16.32	0.07	*B*
	48595.292	15.82	0.03	*V*
	48595.295	15.78	0.03	*V*
	48595.297	15.82	0.04	*V*
	48595.298	15.80	0.03	*V*
	48595.300	15.80	0.03	*V*
	48595.301	15.82	0.03	*V*
	48595.305	15.77	0.03	*V*

Date	JD (2400000+)	Mag	Error	Band
	PKS 0754 + 101			
12/4/91	48595.307	15.80	0.03	*V*
	48595.308	15.78	0.04	*V*
	48595.310	15.84	0.04	*V*
	48595.311	15.78	0.04	*V*
	48595.314	15.78	0.03	*V*
	48595.316	15.79	0.04	*V*
	48595.317	15.74	0.03	*V*
	48595.319	15.78	0.04	*V*
	48595.321	15.79	0.03	*V*
	48595.345	15.77	0.03	*V*
	48595.346	15.77	0.03	*V*
	48595.348	15.75	0.03	*V*
	48595.350	15.73	0.03	*V*
	48595.351	15.76	0.03	*V*
	48595.354	15.75	0.03	*V*
	48595.356	15.73	0.04	*V*
	48595.357	15.76	0.04	*V*
	48595.359	15.74	0.03	*V*
	48595.364	15.73	0.03	*V*
	48595.367	15.77	0.04	*V*
	48595.369	15.74	0.03	*V*
	48595.370	15.77	0.03	*V*
	48595.372	15.79	0.04	*V*
	48595.374	15.78	0.03	*V*
	48595.327	15.38	0.05	*R*
	48595.377	15.32	0.05	*R*
	48595.330	14.89	0.05	*I*
	48595.335	14.75	0.05	*I*
	48595.379	14.83	0.05	*I*
11/7/93	49299.217	15.75	0.05	*B*
	49299.391	15.73	0.05	*B*
	49299.357	15.30	0.03	*V*
	49299.359	15.35	0.03	*V*
	49299.361	15.35	0.03	*V*
	49299.364	15.25	0.03	*V*

Table 1. continued

Date	JD	Mag	Error	Band
11/7/93	49299.367	15.32	0.03	V
	49299.371	15.32	0.03	V
	49299.376	15.32	0.03	V
	49299.379	15.32	0.03	V
	49299.382	15.32	0.03	V
12/4/93	49326.328	16.26	0.11	B
	49326.336	15.72	0.03	V
	49326.283	15.16	0.04	R
	49326.301	15.20	0.05	R
	49326.308	15.19	0.05	R
	49326.313	15.18	0.05	R
	49326.323	14.66	0.05	I
12/5/93	49327.228	15.14	0.05	R
1/7/94	49360.228	15.72	0.03	V
	49360.257	15.77	0.03	V
	49360.267	15.83	0.03	V
	49360.271	15.81	0.03	V
	49360.278	15.77	0.02	V
	49360.285	15.83	0.03	V
	49360.292	15.84	0.03	V
	49360.299	15.85	0.03	V
	49360.309	15.88	0.03	V
	49360.318	15.80	0.03	V
	49360.324	15.77	0.02	V
	49360.330	15.76	0.03	V
	49360.337	15.76	0.03	V
	49360.344	15.74	0.03	V
	B 21156 + 295			
12/4/93	49326.380	16.28	0.07	V
	49326.387	16.11	0.05	R
	49326.394	16.15	0.05	R
	49326.401	16.17	0.05	R
	49326.408	16.12	0.05	R
1/6/94	49359.316	17.43	0.06	V
	49359.326	17.34	0.06	V
	49359.336	17.34	0.06	V
	49359.368	17.28	0.06	V
	49359.383	17.30	0.06	V
	49359.399	17.21	0.06	V

Date	JD	Mag	Error	Band
	3C 334			
5/22/88	47304.268	16.94	0.07	V
	47304.272	17.01	0.08	V
6/9/88	47322.269	17.16	0.06	B
	47322.335	17.12	0.07	B
	47322.274	16.95	0.04	V
	47322.339	16.95	0.05	V
6/10/88	47323.252	17.07	0.06	B
	47323.296	17.17	0.06	B
	47323.352	17.08	0.08	B
	47323.257	17.02	0.05	V
	47323.300	17.01	0.05	V
6/11/88	47324.238	16.94	0.07	V
	47324.283	16.91	0.08	V
6/13/88	47326.149	17.11	0.07	B
	47326.193	17.16	0.06	B
	47326.154	17.00	0.05	V
	47326.199	16.90	0.05	V
	OT 081			
6/7/91	48415.122	17.49	0.09	B
	48415.128	16.73	0.03	V
	48415.136	16.69	0.03	V
	48415.145	16.71	0.03	V
	48415.183	16.70	0.03	V
	48415.189	16.74	0.02	V
	48415.193	16.87	0.02	V
	48415.152	15.92	0.02	R
	48415.177	15.92	0.02	R
6/11/91	48419.105	16.96	0.09	B
	48419.112	17.05	0.08	B
	48419.136	16.26	0.02	V
	48419.143	16.23	0.03	V
	48419.150	16.24	0.03	V
	48419.180	16.25	0.03	V
	48419.196	16.25	0.03	V
	48419.203	16.29	0.03	V
	48419.122	15.60	0.01	R

Date	JD	Mag	Error	Band
	PKS 2128 − 128			
9/27/92	48893.040	15.73	0.11	B
	48893.053	15.47	0.02	V
	48893.058	15.44	0.02	V
	48893.064	15.45	0.02	V
	48893.071	15.47	0.02	V
	48893.077	15.45	0.02	V
	48893.083	15.47	0.02	V
	48893.089	15.47	0.02	V
	48893.095	15.46	0.02	V
	48893.101	15.47	0.02	V
9/30/92	48896.017	15.71	0.11	B
	48896.046	15.74	0.10	B
	48896.065	15.72	0.10	B
	48896.022	15.46	0.02	V
	48896.026	15.45	0.09	V
	48896.030	15.46	0.02	V
	48896.034	15.44	0.02	V
	48896.038	15.45	0.02	V
	48896.041	15.47	0.02	V
	48896.051	15.47	0.02	V
	48896.054	15.46	0.02	V
	48896.057	15.45	0.02	V
	48896.061	15.47	0.02	V
	48896.069	15.46	0.02	V
8/17/93	49217.093	15.87	0.11	B
	49217.099	15.79	0.11	B
	49217.105	15.49	0.02	V
	49217.116	15.48	0.02	V
	49217.123	15.48	0.02	V
	49217.130	15.52	0.02	V
	PKS 2254 + 074			
12/4/91	48594.980	18.27	0.13	B
	48594.986	18.05	0.09	B
	48594.993	17.22	0.06	V
	48594.999	17.23	0.05	V
	48595.040	17.13	0.08	V

Table 1. continued

Date	JD (2400000+)	*Mag*	*Error*	*Band*
12/4/93	49326.042	15.51	0.03	*V*
	49326.047	15.55	0.03	*V*
	49326.052	15.53	0.03	*V*
	49326.058	15.53	0.03	*V*
	49326.067	15.56	0.03	*V*
	49326.073	15.52	0.03	*V*
12/5/93	49326.979	15.98	0.05	*B*
	49326.990	15.45	0.03	*V*
	49326.997	15.46	0.03	*V*
	49327.003	15.52	0.03	*V*
	49327.011	15.46	0.03	*V*
	49327.020	15.48	0.03	*V*
	49327.026	15.49	0.03	*V*
	49327.035	15.52	0.03	*V*
	49327.045	15.49	0.03	*V*
	49327.052	15.51	0.03	*V*
	49327.061	15.49	0.03	*V*
	49327.067	15.54	0.04	*V*
	49327.077	15.50	0.03	*V*
	49327.084	15.49	0.03	*V*
12/6/93	49328.033	15.95	0.05	*B*
	49328.003	15.57	0.03	*V*
	49328.008	15.57	0.03	*V*
	49328.016	15.54	0.03	*V*
	49328.024	15.53	0.03	*V*
	49328.044	15.53	0.03	*V*
	49328.052	15.53	0.03	*V*
	49328.059	15.52	0.03	*V*
	49328.065	15.47	0.03	*V*
11/7/94	49664.129	15.43	0.03	*V*
	49664.140	15.52	0.03	*V*
11/8/94	49665.036	15.76	0.03	*V*
	49665.044	15.73	0.03	*V*

Date	JD (2400000+)	*Mag*	*Error*	*Band*
	PKS 2254 + 074			
12/4/91	48595.044	17.19	0.04	*V*
	48595.005	16.46	0.03	*R*
	48595.010	16.38	0.03	*R*
	48595.014	16.47	0.03	*R*
	48595.019	16.45	0.03	*R*
	48595.023	16.43	0.03	*R*
	48595.027	16.48	0.03	*R*
	48595.030	16.46	0.03	*R*
	48595.034	16.50	0.05	*R*
12/5/91	48595.979	18.01	0.08	*B*
	48595.985	17.20	0.04	*V*
	48595.990	16.42	0.02	*R*
	48595.996	16.40	0.02	*R*
	48596.000	16.47	0.03	*R*
9/27/92	48893.127	18.20	0.16	*B*
	48893.133	18.35	0.19	*B*
	48893.140	16.59	0.03	*R*
	48893.147	16.54	0.03	*R*
	48893.154	16.52	0.03	*R*
9/29/92	48895.080	16.49	0.09	*R*
9/30/92	48896.146	16.72	0.03	*R*
11/7/94	49664.092	15.41	0.04	*V*
	49664.097	15.44	0.04	*V*
11/8/94	49664.972	15.56	0.03	*V*
	49664.986	15.80	0.03	*V*
	PHL 658			
11/7/93	49299.134	15.83	0.06	*B*
	49299.150	15.43	0.05	*V*
	49299.157	15.46	0.04	*V*
	49299.161	15.52	0.03	*V*
	49299.174	15.52	0.03	*V*
	49299.177	15.47	0.03	*V*
	49299.186	15.46	0.04	*V*
12/4/93	49326.018	15.56	0.03	*V*
	49326.024	15.48	0.03	*V*

4.1. PKS 0422+004

The object is a strongly variable radio source with a flat radio spectrum. The optical behaviour for the object has been monitored (e.g. Moles et al. 1985; Worrall et al. 1986; Falomo et al. 1989, 1993; Xie et al. 1988) with changes of spectral slope of $\Delta\alpha = 0.7$ during an optical flare of 8 days, with variations of flux by a factor 2.5 in four days and with short timescale (20 hours) variability with an amplitude $\Delta B \simeq 0.6$ mag. Our photometry for PKS 0422+004 shows variability with maximum amplitude about 0.4 and 0.8 mag in BV band in the interval of about one day and one month respectively (cf. Table 2) and the most rapid variability (timescales from minutes to hours) which appeared in five nights. It will be seen from the light curves in V band in Figs. 4–8 that in 1993 November 7, the luminosity of the object decreased by 0.08 mag in 16 minutes at the begining and increased by 0.09 mag in 33 minutes at the end. In 1993 December 4, the light curve rised by 0.06 mag in 6 minutes and fell by about 0.07 mag and 0.11 mag in the interval of about 22 and 33 minutes respectively. In 1993 December 5, the fastest variability occurring in 26 minutes with an amplitude of 0.17 mag. In 1994 January 6, the light curve twice rised by 0.17 mag and 0.08 mag in the interval of about 42 and 29 minnutes respectively and fell twice 0.13 mag and 0.11 mag in the interval of about 26 and 23 minutes respectively. Finally in 1994 January 7, the luminosity of the object increased by about 0.31 mag in 1.5 hours.

Table 2. Average colour indices and average magnitudes of 8 blazars

UT Date	$\langle B \rangle$	$\langle V \rangle$	$\langle R \rangle$	$\langle I \rangle$	$\langle B-V \rangle$	$\langle V-R \rangle$	$\langle R-I \rangle$
PKS 0422+004							
11/7/87	15.57	15.11			0.46		
	(0.04)	(0.04)			(0.06)		
11/7/93	15.04	14.70			0.34		
	(0.03)	(0.01)			(0.03)		
12/4/93		15.13					
		(0.01)					
12/5/93	15.89	15.50			0.39		
	(0.03)	(0.01)			(0.03)		
12/6/93		15.31					
		(0.02)					
1/6/94	15.38	14.89			0.49		
	(0.03)	(0.01)			(0.03)		
1/7/94		14.90					
		(0.01)					
PKS 0754+101							
12/4/91	16.30	15.78	15.35	14.82	0.50	0.44	0.49
	(0.05)	(0.00)	(0.03)	(0.03)	(0.05)	(0.04)	(0.05)
11/7/93	15.74	15.32			0.44		
	(0.03)	(0.00)			(0.05)		
12/4/93	16.26	15.72	15.18	14.66	0.54	0.54	0.52
	(0.11)	(0.03)	(0.02)	(0.05)	(0.11)	(0.05)	(0.07)
12/5/93			15.14				
			(0.05)				
1/7/94		15.79					
		(0.01)					
B2 1156+295							
12/4/93		16.28	16.14			0.17	
		(0.07)	(0.02)			(0.09)	
1/6/94		17.32					
		(0.02)					
3C 334							
5/22/88		16.97					
		(0.05)					
6/9/88	17.14	16.95			0.19		
	(0.04)	(0.03)			(0.06)		
6/10/88	17.11	17.01			0.10		
	(0.04)	(0.04)			(0.06)		
6/11/88		16.92					
		(0.05)					
6/13/88	17.14	16.95			0.19		
	(0.05)	(0.03)			(0.06)		
OT 081							
6/7/91	17.49	16.75	15.92		0.76	0.79	
	(0.09)	(0.01)	(0.01)		(0.09)	(0.03)	
6/11/91	17.01	16.26	15.60		0.79	0.66	
	(0.06)	(0.01)	(0.01)		(0.08)	(0.02)	

Table 2. continued

UT Date	$<B>$	$<V>$	$<R>$	$<I>$	$<B-V>$	$<V-R>$	$<R-I>$
PKS 2128-117							
9/27/92	15.73 (0.11)	15.46 (0.007)			0.27 (0.11)		
9/30/92	15.73 (0.06)	15.46 (0.007)			0.27 (0.06)		
8/17/93	15.83 (0.08)	15.49 (0.01)			0.34 (0.08)		
PKS 2254+074							
12/4/91	18.12 (0.08)	17.20 (0.03)	16.45 (0.01)		0.83 (0.11)	0.63 (0.09)	
12/5/91	18.01 (0.08)	17.20 (0.04)	16.43 (0.01)		0.81 (0.09)	0.78 (0.04)	
9/27/92	18.26 (0.12)		16.55 (0.02)				
PKS 2254+074							
9/29/92			16.49 (0.09)				
9/30/92			16.72 (0.03)				
11/7/94		15.43 (0.03)					
11/8/94		15.68 (0.02)					
PHL 658							
11/7/93	15.83 (0.06)	15.49 (0.02)			0.40 (0.08)		
12/4/93		15.53 (0.01)					
12/5/93	15.98 (0.05)	15.49 (0.01)			0.46 (0.06)		
12/6/93	15.95 (0.05)	15.53 (0.01)			0.42 (0.06)		
11/7/94		15.47 (0.02)					
11/8/94		15.74 (0.02)					

The uncertainties of the comparison stars intercalibrated are 0.04 mag at V band for all of them and 0.04, 0.05 and 0.06 mag in B band for B, E and F respectively.

4.2. PKS 0754+101

Tapia et al. (1977) discovered the BL Lacertae object PKS 0754+101 ($z = 0.66$) during a polarization survey program. Flickering by as much as 0.8 mag is superimposed on slower variations spanning 1 or 2 years (Pica et al. 1988). Variations on time scale of a day and 80 minutes were observed by Smith et al. (1987) and Xie et al. (1991) respectively.

In our monitoring, the luminosity increased by 0.56 and 0.46 mag in the B and V bands respectively from 1991 to 1993 November and then decreased by 0.52 at B and by 0.4 mag at V in the interval of a month (cf. Table 2), down to the level in 1991. A drop with an amplitude of 0.16 mag and then a rise of 0.14 mag in the V band were seen on time scales of about 116 and 50 minutes respectively on 1994 January 7 (Fig. 1). The uncertainties of the comparison stars A, B, C, and G intercalibrated all are 0.04 mag at V band. In the B and R bands, the magnitudes and uncertainties of the only used comparison stars A and B are taken from Smith et al. (1985).

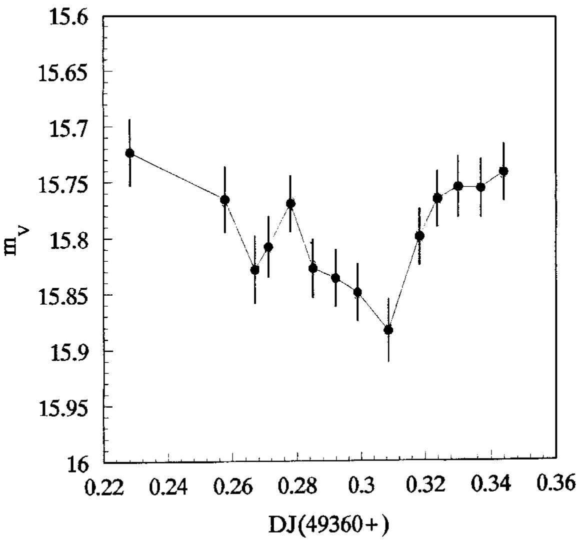

Fig. 1. Light curve 0f PKS 0754+101 in the V band on January 7, 1994

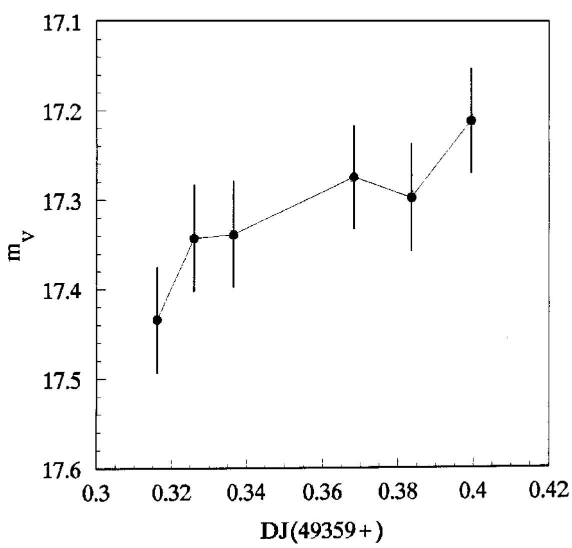

Fig. 2. Light curve of B2 1156+295 in the V band on January 6, 1994

4.3. B2 1156+295

The quasar B2 1156+295 ($z = 0.729$) was first identified by Wills (1966) as the optical conterpart of the radio source 4C 29.45 and is one of the most variable object observed. A 5 mag optical outburst in the object occured

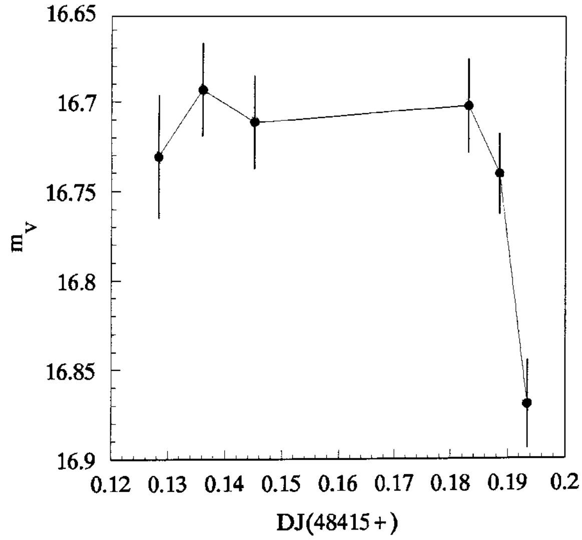

Fig. 3. Light curve of OT 081 in the V band on June 7, 1991

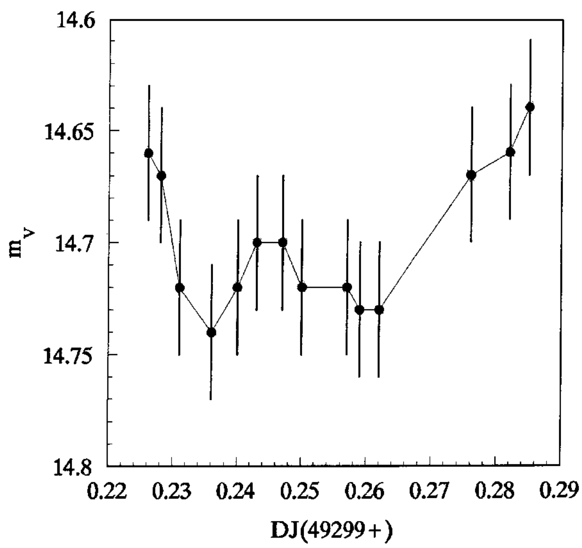

Fig. 4. Light curve of 0422+004 in the V band in 1993 Nov. 7

in the spring of 1981 (Wills et al. 1983). During our observations, the amplitude of varitions in V band reached 1.04 mag in the interval of one month (cf. Table 2) and variations of $\Delta V \approx 0.22$ mag were seen on a time scale of about 2 hours on 1994 January 6 (Fig. 2). The magnitude and its error of the only used comparison star 15 are taken from Smith et al. (1985).

4.4. 3C 334

3C 334 is a radio-loud object ($z = 0.555$) with a steep radio spectrum and flat optical continuum. Smith et al. (1993) suggested that it has a period of variations about 15 years. During our observations the object was fainter and no obvious variations were seen. The uncertainties on the intercalibrated comparison stars D and E are $0^{\rm m}_{.}06$ and $0^{\rm m}_{.}04$ for B and V band respectively.

4.5. OT 081

OT 081 ($z = 0.32$) is a rapidly variable source. An outburst with amplitude 1.56 mag at B band was seen on April 11, 1979 (Pica et al. 1980). Rapid variations with a time scale about 40 minutes were recorded in 1990 (Xie et al. 1992).

In our observations, the V magnitude increased by $0^{\rm m}_{.}17 \pm 0^{\rm m}_{.}036$ in 15 minutes on 1991 June 7 (Fig. 3), and in a interval of four days the change of fluxes reached 56% in the B and V bands and 34% at R band (cf. Table 2). The uncertainties of comparison stars A, B, D, and G intercalibrated at V band are $0^{\rm m}_{.}02, 0^{\rm m}_{.}03, 0^{\rm m}_{.}06$ and $0^{\rm m}_{.}07$ respectively, in the B band the only used intercalibrated D and G stars have errors $0^{\rm m}_{.}06$ and $0^{\rm m}_{.}05$ respectively, and in the R band, the used B, D and G stars all have a $0^{\rm m}_{.}01$ uncertainty.

4.6. PKS 2254+074

2254+075 (OY 091) is a rapidly variable source with a flat radio and steep optical spectrum. Its redshifts ($z = 0.19$) was determined by Stickel et al. (1988). It flared by 1.8 mag in 1981 (Pica et al. 1988). In 1987 and 1989 Xie et al. (1992) observed variations on time scales of several tens of minutes.

In our observations during 1991-1992 the object was faint ($V = 17.2$), No variations beyond three standard deviations were seen on time scales of tens of minutes within one night. There were variations $\Delta R \simeq 0.17 \pm 0.036$ mag in a interval of three days. But at the end of 1994 the luminosity of the object increased to $V \approx 15.56$ mag, and variations by $\Delta V \simeq 0.25 \pm 0.035$ mag appeared in one night. On 1994 November 8 variations with an amplitude 0.24 ± 0.04 mag were observed in 20 minutes in the V band (cf. Table 2 and Table 1). The comparison stars C, D, E, and H are intercalibrated, their uncertainties are $0^{\rm m}_{.}04, 0^{\rm m}_{.}06, 0^{\rm m}_{.}03$ and $0^{\rm m}_{.}04$ respectively in the B band and are $0^{\rm m}_{.}04$ for C and E stars and $0^{\rm m}_{.}06, 0^{\rm m}_{.}03$ for D and H respectively in the V band. In the R band they were $0^{\rm m}_{.}02$ for the C, D, H stars and $0^{\rm m}_{.}03$ for the E star.

4.7. PHL 658

PHL 658 is active historically (Barbieri et al. 1979). In 1991–1992 our observations showed only variations by 0.1 mag in a interval of about 10 months (Guibin et al. 1995). The present data show that the object was brightening from 1991 to 1994 and came into activity in 1994. In November/1994 variations by $\Delta V \simeq 0.27 \pm 0.03$ mag were seen in the interval of one day (cf. Tables 1 and 2). Variations in short time scales are expected, and we will go on monitoring the object. The uncertainties of the used comparison stars A and F are the same as thoes in the preceding paper (Guibin et al. 1995).

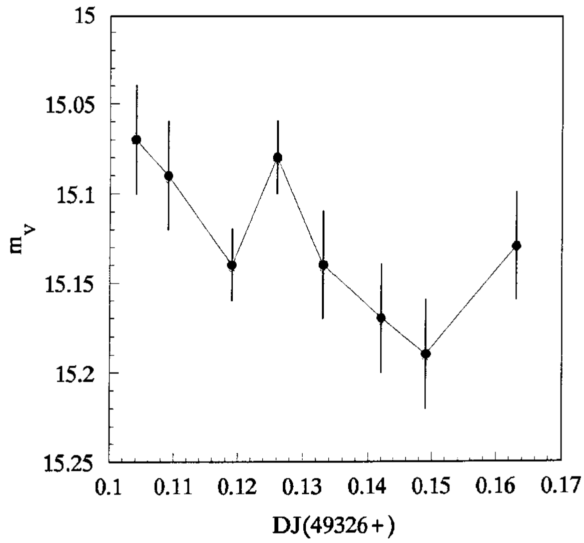

Fig. 5. Light curve of 0422+004 in the V band in 1993 Dec. 4

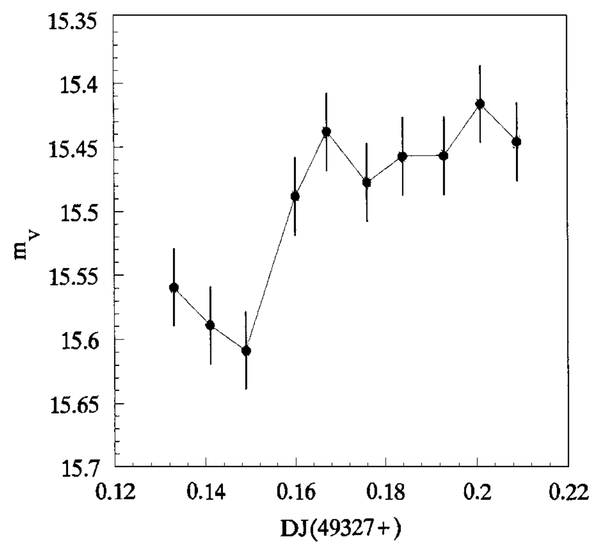

Fig. 6. light curve of 0422+004 in the V band in 1993 Dec. 5

4.8. PKS $2128-123$

This object is a well-known variable radio quasar ($Z = 0.501$) with a flat radio spectrum. Moles et al. (1985) observed variability with a timescale of 105 minutes and with an amplitude increasing with wavelength reaching 0.08 mag in V band. Optical long -term monitoring (e.g. Pica et al. 1988; Smith et al. 1993) showed a variability

Table 3. Properties of nine objects with flat spectra and known redshifts

Name	Z	m_v (mag)	lg(Δt) (sec)	Δm_v (mag)	$L(\times 10^{46})$ (ergs s^{-1})	η	δ
PHL 658	0.450	15.47	4.90	0.27	1.820	0.04	
		(15.38)	(3.26)	(0.15)	(1.980)	(1.10)	
3C 120	0.033	14.79	3.08	0.21	0.037	0.03	3.41
0745+101	0.660	15.74	3.48	0.14	2.563	1.99	0.49
OJ 287	0.306	14.15	2.78	0.12	2.531	3.10	3.10
B2 1156+295	0.729	17.21	3.86	0.22	0.724	0.18	3.15
3C 345	0.595	16.96	4.94	0.09	0.634	0.01	3.25
		(17.50)	(2.89)	(0.47)	(0.385)	1.71	
OT 081	0.320	16.70	2.95	0.17	0.404	0.47	7.01
2128-123	0.501	(15.99)	(3.80)	(0.08)	(1.436)	0.13	
2254+074	0.190	15.56	3.08	0.24	0.354	0.39	0.04

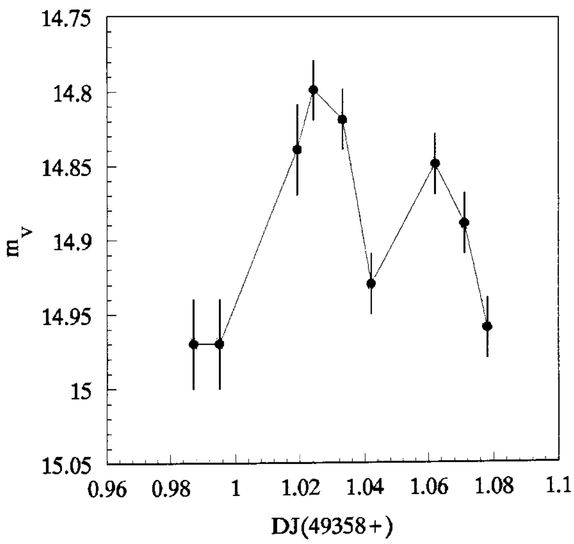

Fig. 7. Light curve of 0422+004 in the V band in 1994 Jan. 6

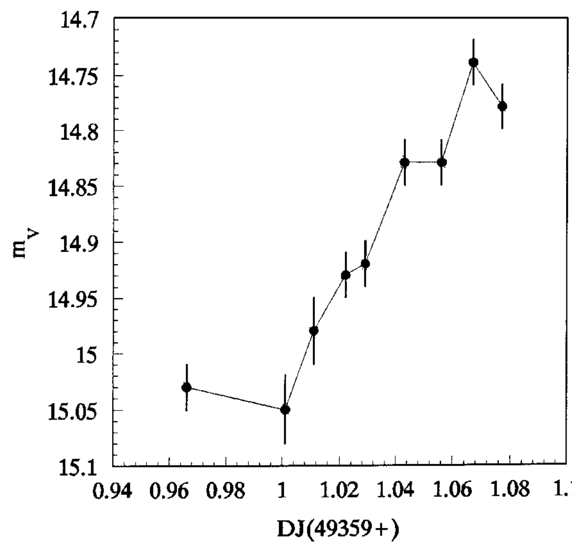

Fig. 8. light curve of 0422+004 in the V band in 1994 Jan. 7

with 13 years period. Our observations show no variability in the B and V bands at any timescales. The uncertainties of intercalibrated comparison stars are $0\overset{m}{.}14$ in the B band and $0\overset{m}{.}025$ in the V band for both the B and G stars.

5. Model and discussion

Ten out of eleven blazars in this paper and in Guibin et al. (1995) are radio loud sources with a radio flat spectrum, other one PKS 1618+177 is a object with a radio steep spectrum. The objects with a flat spectra exhibit day-today variability except for PKS $2128-123$, and seven such objects show a more rapid variability with timescales of tens minutes to 2 hours. In all probability, variability at the shortest time scales is intrinsic (Wagner et al. 1995 and references therein). Relativistic beaming model can provide an explanation of the variability of blazars. The efficiency for conversion of accreted matter into energy in a spherical, homogeneous, non-relativisticaly beamed source is given by

$$\eta \geq 5.0 \times 10^{-43} \frac{\Delta L}{\Delta t}, \tag{1}$$

where ΔL, in ergs s^{-1}, is the variation in luminosity within the time interval Δt in seconds. Relativistic beaming is infered if the value of η exceeds 0.1 (Guilbert et al. 1983). Table 3 gives the luminosity and the efficiency for objects with flat spectra except for PKS 0422+004, assuming $H_0 = 50$ km s^{-1}Mpc^{-1} and $q_0 = 0$ and performing the K-correction and correction of the galactic extinction. The bolometric luminosity L, the efficiency and the Doppler factor δ are given in Cols. 6, 7 and 8 respectively, the timescale Δt and amplitude Δm_v of variability observed at the magnitude m_v are also listed, taken from this paper and from Guibin et al. (1995) and from another paper submitted to A&A for OJ 287. The observed values between brackets are from Barbieri et al. (1979) for PHL 658, Kidger et al. (1990) for 3C 345 and Moles et al. (1985) for $2128-123$. The B mag given by Barbieri et al. (1979) and Kidger et al. (1990) and the I mag for OJ 287 were normalized to the value in V band (showed between brackets) using the known colour index and assuming that the variations in V band are the same as those in B and I band. The value of δ is calculated according to the formula and the parameter values given by Ghisellini et al. (1993) except for the parameters of F_x and ν_x that are replaced by the flux at the corrected V magnitude during our observations of variability and by ν_v respectively.

It will be seen from Table 3 that the efficiencies derived from our observations are larger than 0.1 except for PHL 658, 3C 345 and 3C 120. However, other observations show that $\eta > 0.1$ for PHL 658 and 3C 345; The δ values for the objects are larger than one except for PKS 0754+101 and PKS 2254+074, both of which have $\eta > 0.1$. If $\eta > 0.1$, the Doppler factor should be larger than one in the relativistic beaming model. In conclusion, it seems that relativistic beaming exists for all objects.

Acknowledgements. The authors express their thanks to staff of the Yunnan Base, Optical Union Opening Observatory and of the computer department for their assistance during observations and data processing. We thanks the astronomical committee of the Chinese Academy of Science for financial support.

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