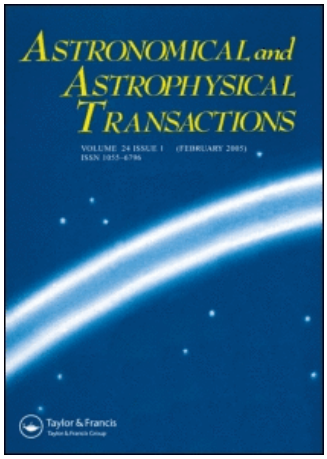

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UBVRI OBSERVATIONS OF VARIABILITY OF NUCLEI OF THE SEYFERT GALAXIES NGC 1275 AND NGC 4151. RAPID FLARES ON LIGHT CURVES OF THE GALAXY NGC 1275

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Simultaneous UBVRI observations of the Seyfert galaxies NGC 1275 and NGC 4151 were obtained since 1989 till 1994. The unusual brightening of the NGC 4151 nucleus was accompanied by reddening of the blue region of its spectrum. Variations in brightness and colour indices of the NGC 1275 nucleus are complicated and unsynchronous. There are fast flares of two types on light curves within one night. Type I flares are characterized by maximal changes in U filter. During the flare of type II maximum flux increase in I band is accompanied by the constant flux in U band. Amplitudes of observed flares were 5–20%, their durations were 15–30 minutes.

KEY WORDS Seyfert galaxies, UBVRI photometry

Seyfert galaxy nuclei are known to be variable at different wave-lengths and time-scales with different amplitudes.

1 OBSERVATIONS

Observations were carried out with the 1.25 m telescope of the Crimean Astrophysical Observatory, equipped with a Double Image Chopping Photometer – Polarimeter by Prof. V. Piirola (1973) from Helsinky University. This device allows us to obtain simultaneous observations in 5 filters of Johnson's UBVRI system.

The observations were done by the conventional technique of differential measurements of variable stars. Two comparison stars were applied, the second one used for check purposes. The stars were taken from the list by Lyutyi (1980). Time resolution was about 3–4 minutes, we made 8 integrations of 10 sec each.

Photon statistics (corrected for sky background) is applied to calculate photometric errors, which used to be the same as r.m.s. errors obtained by averaging 8 integrations. As a rule, photometric errors were less than 0.01 mag, the signal – to – noice ratio was $S/N \sim 35$–100.

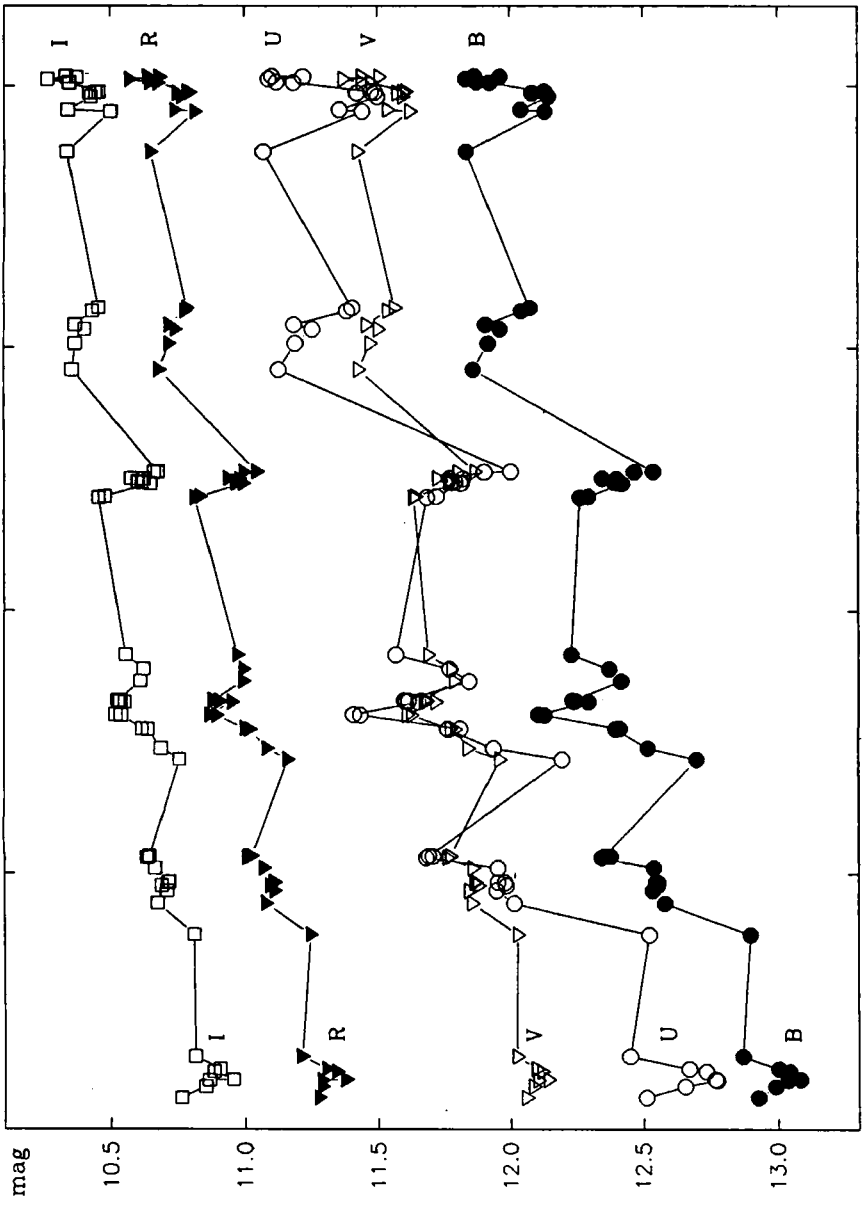

Figure 1 NGC 4151 in a $D = 20''$ diaphragm. All data are averaged for each night.

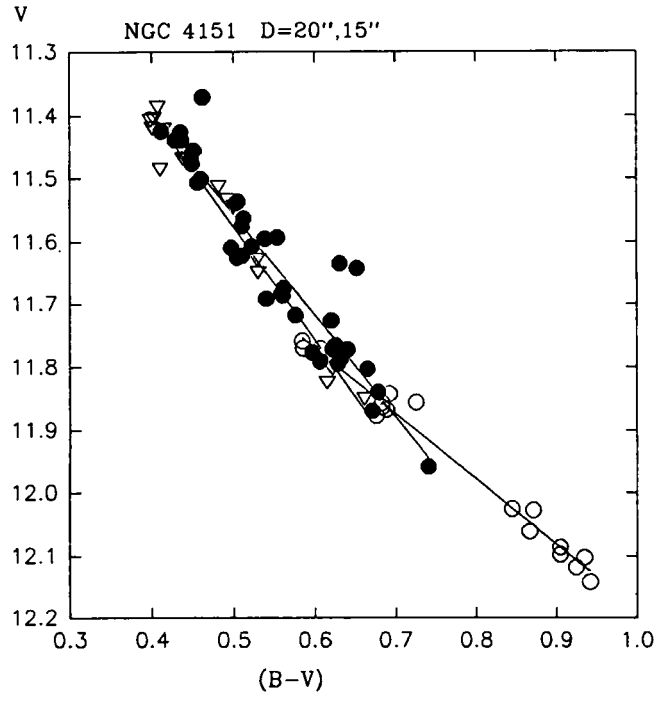

Figure 2 Open circles, JD 2447569–8033; dots, JD 2448216–9517, $D = 20''$. Triangles, JD 2448743–9488, $D = 15''$.

The telescope is fully automated, during observations we employed an autoguider. The galactic nuclei monitoring was made in good atmospheric conditions, estimated seeing was in the range of 1–3 arcsec for all nights.

1.1 NGC 4151 (Type Sy 1.5)

In total, 770 observations were made during 58 nights in six observational runs (JD 2447569–9517) using a 20″ diaphragm. Stellar magnitudes averaged for each night are shown in Figure 1 (note that errors do not exceed the size of the symbols in all plots). We also obtained about 400 estimates during JD 2448743–9488 using 15″ and 10″ apertures.

There is a clear tendency of the nucleus to brighten in the U band twice more than in the I band ($\Delta U = 1^{\rm m}.70$; $\Delta B = 1^{\rm m}.25$; $\Delta V = 0^{\rm m}.77$; $\Delta R = 0^{\rm m}.81$; $\Delta I = 0^{\rm m}.69$). Colour indices reflect the behaviour of the nucleus brightness.

Colour-magnitude dependences are well expressed; for instance, see Figure 2. However, data for last observational runs, represented by dots and triangles, corresponding to 20″ and 15″ diaphragms respectively, considerably deviate from the straight line drawn through the open circles. This may be caused by flux ascending in the blue spectral region.

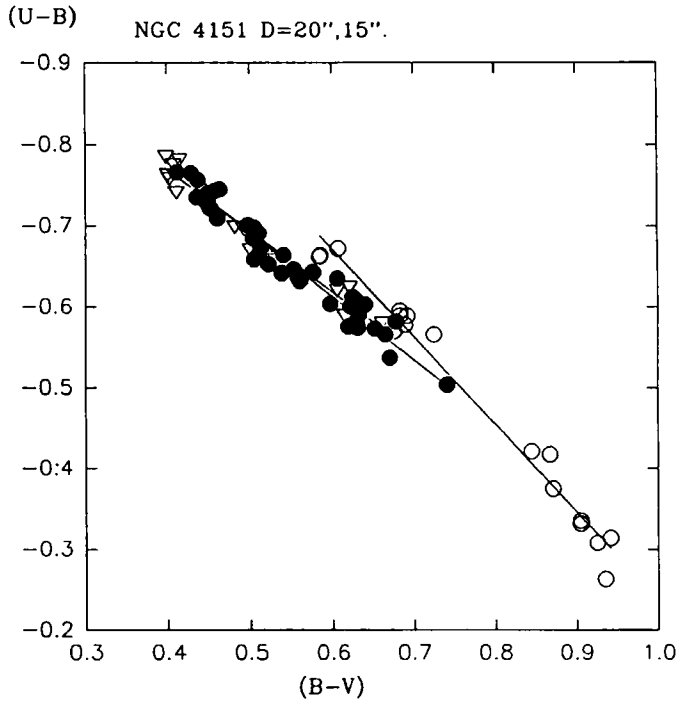

Figure 3 Open circles, JD 2447569–8033; dots, JD 2448216–9517, $D = 20''$. Triangles, JD 2448743–9488, $D = 15''$.

The two – colour diagram is plotted in Figure 3. We conclude that during the last observational runs the colour indices of NGC 4151 were higher and its nucleus became "redder" than in previous seasons. The unusual brightening of the NGC 4151 nucleus was accompanied by its reddening.

Figure 4 represents fluxes in V band versus those in U band. There is no difference between data obtained in $20''$ and $15''$ apertures. This means that we can see only fluxes from the galactic nucleus during the epoch of brightness maximum.

1.2 NGC 1275 (Type Sy2 or BL LAC)

Since the end of the 70-ies until now the nucleus is in the long photometric minimum. One can observe only small fluctuations of its brightness. We noted this fact earlier (Merkulova, Metik, Pronik, 1993). Analysis of our narrow-band photometry of this nucleus obtained in 1983–1987 together with the V band photometry by Lyutyi enables us to suppose that there is no correlation between brightness and time.

The colour – magnitude diagrams are not informative in the case of the NGC 1275 nucleus because of great scatter of data and small colour fluctuations. The

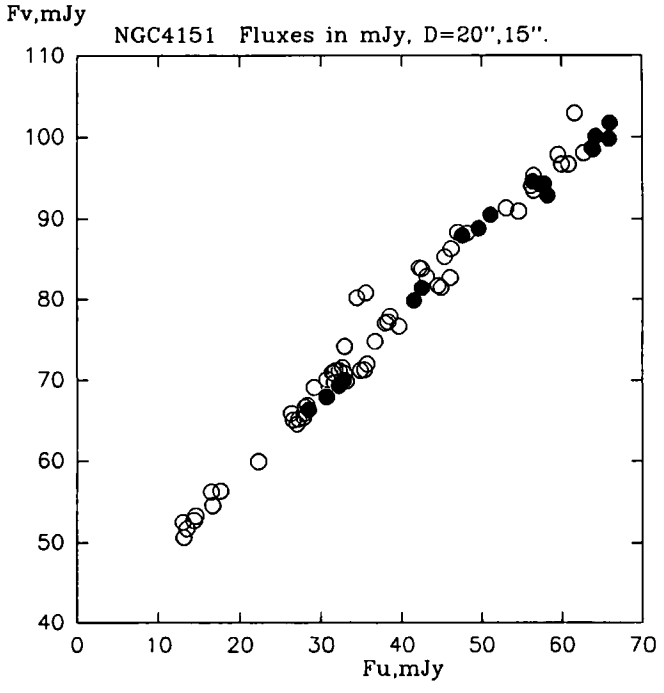

Figure 4 Open circles, $D = 20''$. Dots, $D = 15''$.

large scatter of colour indices in two–colour diagrams also exceeded observational errors (Merkulova, Metik, 1995).

Complicated and unsynchronous changes of brightness and colour indices both in ultraviolet and red spectral regions permit us to suppose two variable sources in the NGC 1275 nucleus.

2 RAPID FLARES ON THE LIGHT CURVE OF THE GALAXY NGC 1275

Analyzing light curves of the galaxy NGC 1275 within one night, we discovered rapid flares of two types. Type I flares are characterized by the greatest increases or decreases of flux in U band whereas minimal changes take place in I band. During the flare of type II, flux increase in I filter is accompanied by constant flux in U filter (within observational errors) or even by its decrease by 3–4%. Amplitudes of observed flares were 5–15%, their durations were 15–30 minutes.

One can see 3 events of both types in Figure 5. Averaged moment of observation is plotted along the horizontal axis. Each observation lasts about 3–4 minutes and consists of 8 brightness estimates obtained simultaneously in 5 filters and averaged, accounting for their standard deviation. Each point on plots represents one ob-

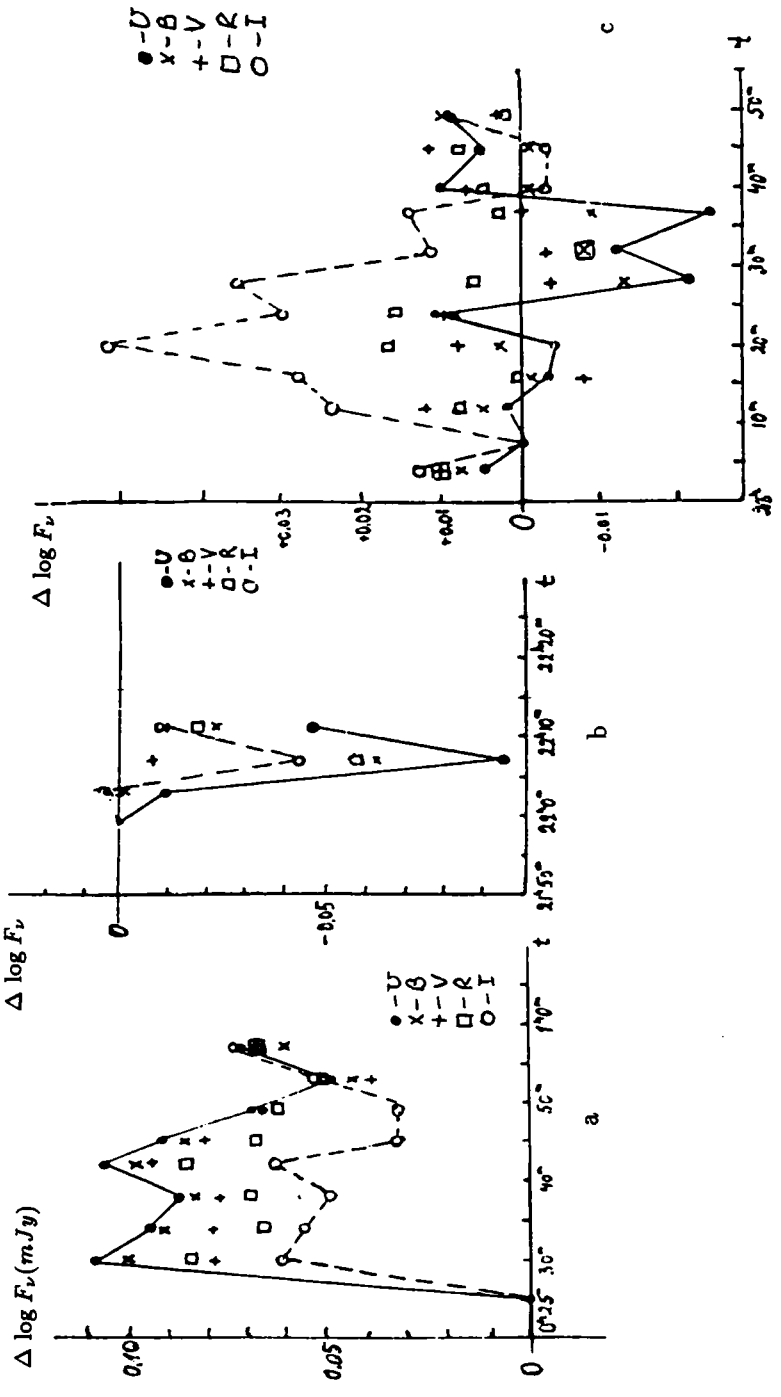

Figure 5 Rapid flares of different types occur on light curves of NGC 1275 (see text). Different signs represent fluxes in different bands.

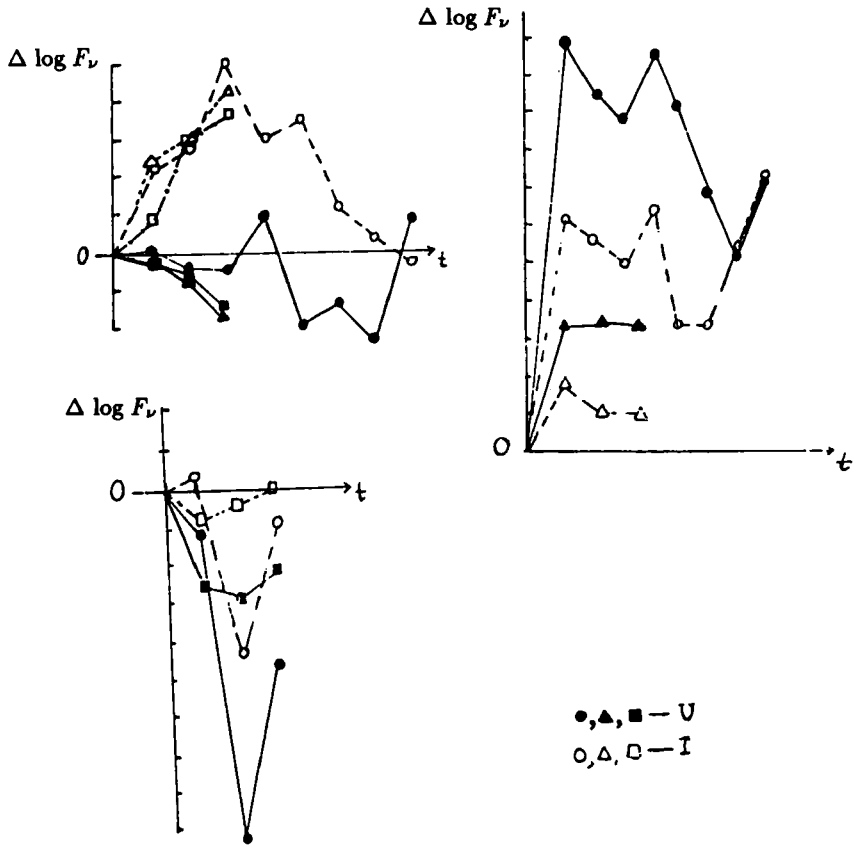

Figure 6 Composite flares of different types.

servation. Vertical axes show differences between logarithms of flux densities (in mJy):

$$\Delta \log F_\nu = \Delta \log F_\nu(t) - \Delta \log F_\nu(t_0)$$

for two moments of the event, where t_0 is the beginning of the flare.

Figure 5a demonstrates the flare of type I which happened on 21–22.11.1990. Its duration was about half an hour. The amplitude in U filter amounts to 30% of the total flux at the moment of flare beginning, whereas in I band the flux density increased by about 15%. Flux variations in other filters follow those in U filter and show intermediate changes compared to fluxes in U and I filters (i.e. between maximum and minimum variations).

Figure 5b presents one of "negative" flares. The decrease of flux density in U band approaches 24%, but in I filter – it is only about 11%. This event happened on 7–8.02.1991, its duration was about 15 minutes.

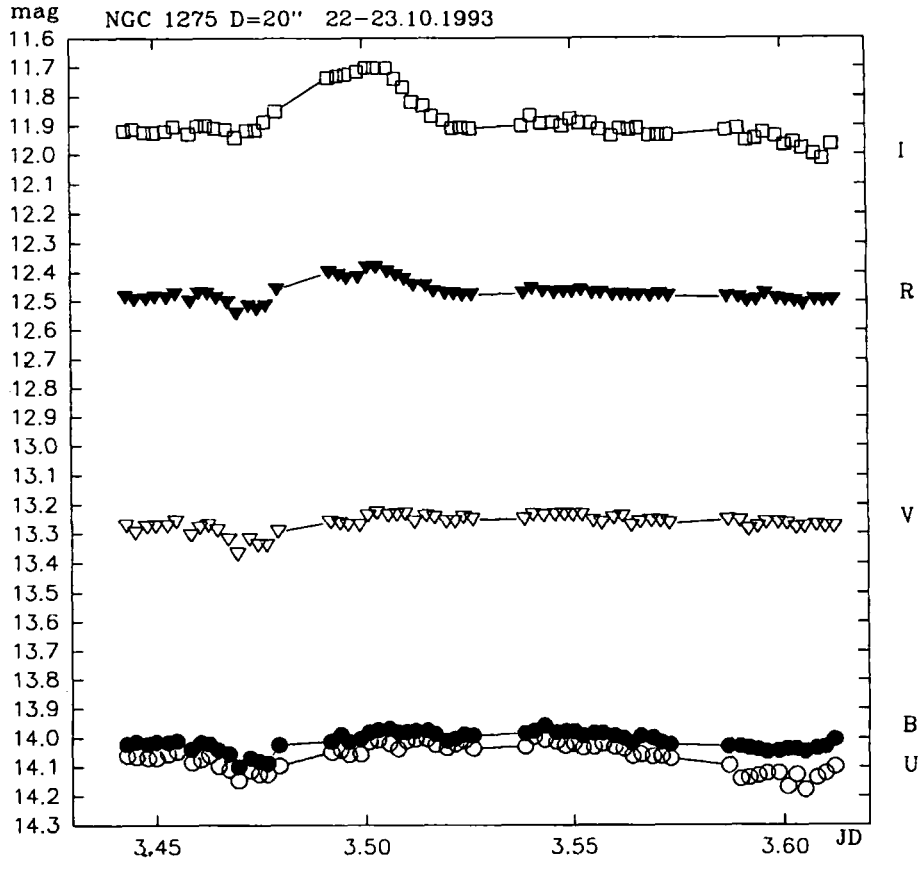

Figure 7 A red flare of the NGC 1275 nucleus.

The flare of type II is shown in Figure 5c. The date of observation is 17–18.01.1991. Flux density in I band increased by 13% compared to the flare beginning, but it was constant in U band, and then it even decreased by 6% in this filter. This event continued about 30 minutes.

Unfortunately, we are able to show here only a small part of flares.

Figure 6 shows composite flares formed from two or three separate events. These pictures display the behaviour of flux densities only in U (closed symbols) and I (open symbols) bands. All these flares were observed on different nights.

We observed a very interesting flare on 22–23.10.1992. It was a red flare of type II with duration of $\sim$ 85 minutes. Data obtained during this night are represented in Figure 7.

Acknowledgement

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