OPTICAL VARIABILITY OF THE *N* GALAXY 3C 371

M. K. BABADZANJANZ and E. T. BELOKON'
University of Leningrad, U.S.S.R.

Abstract. On the basis of a uniform series of photographic observations a 163 day period for the light variations of the *N* galaxy 3C 371 is found. The similarity of the form of the light curve for the different components of the light variations with the different time scales is noted. The form of the light variations was observed to be identical to that of the quasars 3C 345 and 3C 454.3.

It is clear that the regular and moreover periodic variation of the emission intensiy (when the amplitude is significant) is an intrinsic characteristic of the system's structure. For only a few quasars and galactic nuclei are there indications of periodicity in the light variations. But even in these cases the period values are controversial or the very periodicity is questioned. One of the main reasons of such a situation is the poor quality of the observational data.

We analyzed the light variability of the *N* galaxy 3C 371. In this analysis a rather uniform and numerous series of observations obtained in the photographic patrol programme carried out at the Leningrad University Astronomical Observatory since 1968 (Babadzanjanz *et al.*, 1973a, b, 1974) were utilized. The observational data were obtained with the 48-cm (*F*/4) reflector in the B color. The data for each night were averaged. The rms error of one brightness evaluation is $0^m.03$–$0^m.10$, depending on the number of averaged plates.

All the values of the brightness of 3C 371 since 1966 which we possess are shown in Figure 1. In addition to the data (Babadzanjanz *et al.*, 1973a, b, 1974) we also

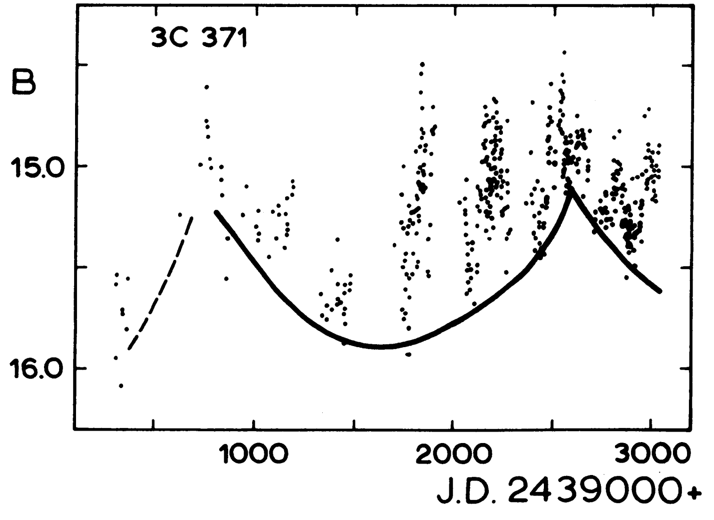

Fig. 1. Light curve of 3C 371 (1966–1973). Component I is indicated by the solid line. Beginning from J.D. 2440706.6 the I components in Figure 1 and Figure 2 are identical.

Sherwood and Plaut (eds.), Variable Stars and Stellar Evolution, 611–614. *All Rights Reserved.*

https://doi.org/10.1017/S007418090001086X Published online by Cambridge University Press

used the observations by Sandage (1967, 1973), Cannon *et al.* (1971), Usher *et al.* (1969), and Nebelitsky (1972a, b). The maximum systematic difference of the brightness evaluations from all these sources never exceeded $0\overset{m}{.}2$ (Babadzanjanz, 1974).

The light variations may be divided into 2 components: (1), a 'slow' one with a $0\overset{m}{.}8$ amplitude and a time scale of 2.5 yr, and (2) a rapid one with a $0\overset{m}{.}3$–$1\overset{m}{.}2$ amplitude and a time scale of 1–100 days. The possible periodicity of component II was tested by a modification of the 'trial period' method proposed by Jurkevich (1971). The sum of the rms deviations from the mean value (V_m^2) in each subdivision of the whole phase interval was taken as the statistics. At first, the period from J. D. 2440706 to J.D. 2441650, i.e. to the break down of component I level was used for the analysis (Babadzanjanz and Belokon', 1974). This interval comprises 263 brightness evaluations from Babadzanjanz (1973a, b, 1974), 15 photoelectrical evaluations by Nebelitsky (1972a) and a single observation (J.D. 2440706.6) by Cannon *et al.* (1971). To increase the sensitivity of the method of analysis it is necessary to filter out the low frequencies if their amplitude is comparable with that of the investigated frequencies.

In Figures 1 and 2 the level of the low frequency component is traced. The values of this component must be substracted from the initial data. Since we cannot take into account in such a direct manner the probably existing component with the time scale

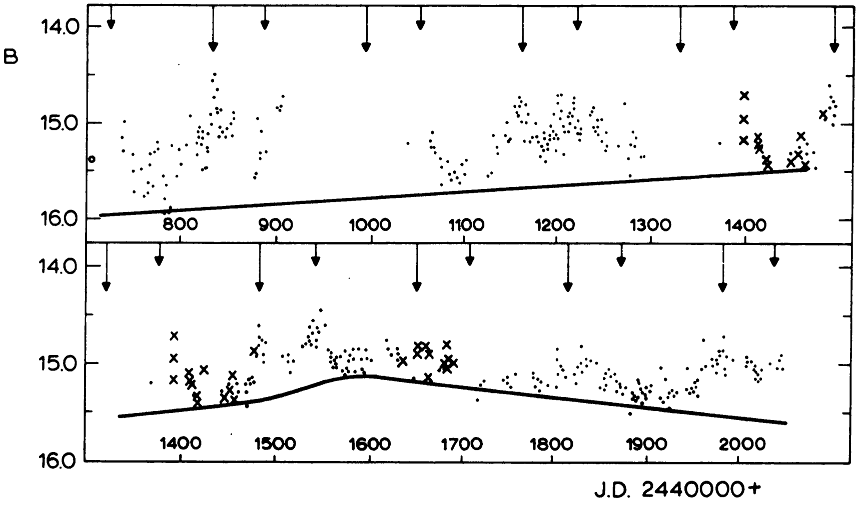

Fig. 2. Light curve of 3C 371 (1970–1973). ○ – Cannon *et al.*, ● – Babadzanjanz *et al.*; × – Nebelitsky. The predicted maxima of the 163-day period are indicated by the arrows.

less than 5 yr, we tried to reduce its influence by an indirect method. The observations obtained in each observational season were averaged and the line equally distant from the smooth (5 yr) curve was traced through the average points. This line gave the values to be substracted from the observed ones. The quantities ΔB obtained by such a technique were used for the periodicity analysis.

In Figure 3 the dependence of V_m^2 on the trial period values is shown. Its minimum indicates the existence of a period, $P \simeq 165^d$. That this is not an accidental deviation of V_m^2 is confirmed by a minimum at $P \simeq 325^d (\simeq 165 \times 2)$ and a deep depression at $P > 500^d$. After making the results more precise by directly using the brightness curve with the aid of the sharply distinguished local light maxima, the period $P = 163^d$ was obtained. Figure 4 shows the mean light curve traced for this value of the period. The ΔB for different intervals of time equal to the period are indicated by the different signs. Six cycles of the 163 day period are contained in the whole analyzed interval of observations. (The observational data is too scanty to comment on the periodicity before J.D. 2440706.)

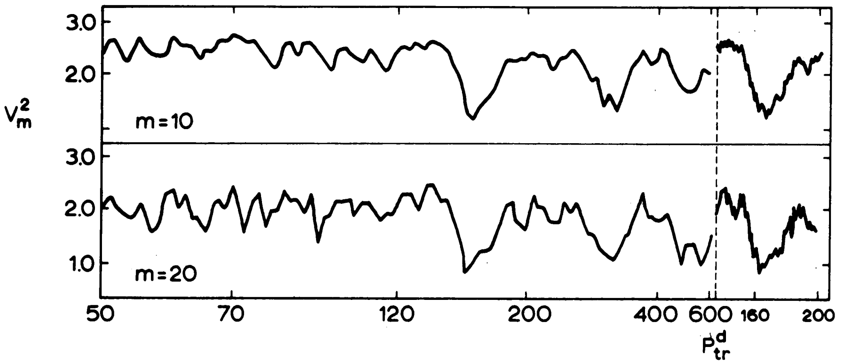

Fig. 3. The statistic $V_m{}^2$ is plotted against the trial period for the values ΔB of 3C 371. The scale between the marked values of the trial period is uniform. The values of $V_m{}^2$ calculated with the decreased step of the trial period are shown to the right of the vertical dashed line. The parameter *m* allows one to vary the degree of smoothing of the statistic.

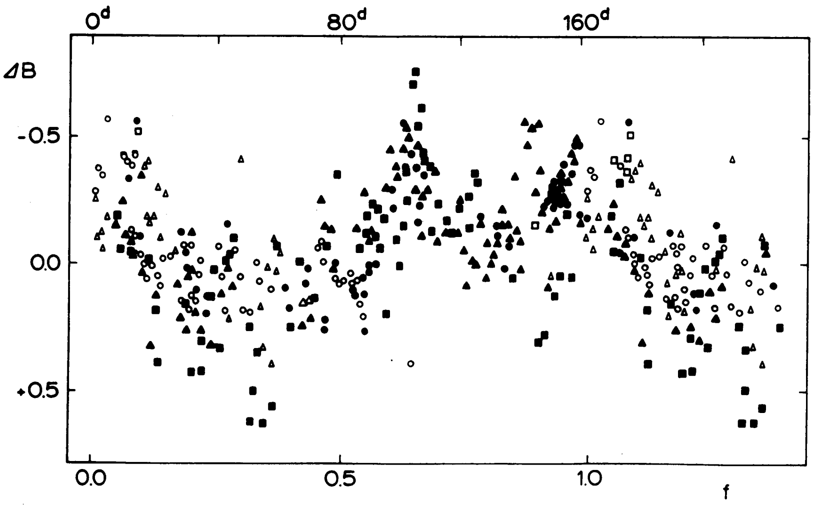

Fig. 4. The mean light curve of component II of variation of the *N* galaxy 3C 371. The values ΔB are plotted against the phase of the 163-day period. The ΔB for different intervals of time equal to the period are indicated by the different signs.

The characteristic property of the mean light curve is the existence of a flat minimum and a sharply peaked maximum; the secondary rise of the brightness (phase 0.85–1.05) is probably less synchronized with the factor determining the periodicity.

Near J.D. 2441600 a sharp breakdown of the component I variation took place (Figure 1). The maximum of component II which would occur at this moment of time was absent (Figure 2). However later the typical form of component II was re-established (J.D. 2441850–2442050; the main maximum occurred at the predicted time), while for a definitive conclusion the observing interval is insufficient.

We note great similarity between the light curve form (a flat minimum and peak-like rise of the brightness) for the components with time scale $\sim 160^d$ (Figure 4), the 5 yr component (Figure 1) and the 100-yr component (Usher *et al.*, 1969). Their amplitudes are also similar ($\sim 1^m$).

Such a form of the light curve does not seem to be a characteristic feature of *N* galaxies, for behavior of the optical variability of the *N* galaxy 3C 390.3 differ essentially from that of 3C 371. At the same time, the 5-yr component of the quasar 3C 345 (Babadzanjanz *et al.*, 1974) and the variable component of the quasar 3C 454.3, proposed periodic by Lü and Hunter (1969), are similar to the variable components of 3C 371.

In conclusion we would note that such a rather strong periodicity of the optical variability of 3C 371 may take place only within some limited intervals of time, like the phenomenon of the quasar 3C 345 (Kinman *et al.*, 1968).

References

Babadzanjanz, M. K.: 1974, Dissertation, Leningrad Univ.

Babadzanjanz, M. K. and Belokon', E. T.: 1974, *Astron. Tsirk. U.S.S.R.*, No. 819, 3.

Babadzanjanz, M. K., Hagen-Thorn, V. A., Kopatskaja, E. N., Nebelitsky, V. B., and Poljanskaja, E. I.: 1973a, *Trudi Astron. Obs. Leningrad. Univ.* **29**, 72.

Babadzanjanz, M. K., Vinokurov, S. K., Hagen-Thorn, V. A., and Semenova, E. V.: 1973b, *Trudi Astron. Obs. Leningrad Univ.* **30**, 69.

Babadzanjanz, M. K., Vinokurov, S. K., Hagen-Thorn, V. A., and Semonova, E. V.: 1974, *Trudi Astron. Obs. Leningrad Univ.* **31**, 76.

Cannon, R. D., Penston, M. V., and Brett, R. A.: 1971, *Monthly Notices Roy. Astron. Soc.* **152**, 79.

Jurkevich, I.: 1971, *Astrophys. Space Sci.* **13**, 154.

Kinman, T. D., Lamla, E. L., Cuirla, T., Harlan, E., and Wirtanen, C. A.: 1968, *Astrophys. J.* **152**, 357.

Lü, P. K. and Hunter, J. H.: 1969, *Nature*, **221**, 755.

Nebelitsky, V. B.: 1972a, *Astron. Tsirk. U.S.S.R.*, No. 732.

Nebelitsky, V. B.: 1972b, *Astron. Tsirk. U.S.S.R.*, No. 764.

Sandage, A.: 1967, *Astrophys. J.* **150**, L177.

Sandage, A.: 1973, *Astrophys. J.* **178**, 25.

Usher, P. D., Cannon, R. D., and Penston, M. V.: 1969, *Observatory* **89**, 198.