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BVRcIc PHOTOMETRIC MONITORING OF THE SEYFERT GALAXY NGC 3516 IN 2017-2021

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The results of BVRcIc photometric observations of the Seyfert galaxy NGC 3516, conducted in 2017-2021, are presented. The obtained results show that the change in brightness within the observation carried out within the period of 2017-2021 in the BV Rc and Ic filters was 0.36 ± 0.005 ; 0.28 ± 0.005 ; 0.07 ± 0.003 and 0.04 ± 0.004 magnitudes, respectively. This fact proves that there was a change in the spectral type in this galaxy, which was obtained as a result of spectral observations.

Keywords: Seyfert galaxy – NGC 3516 – AGN – CL AGN – UV – optical – photometry – spectroscopy –

1. INTRODUCTION

The variability of the radiation of Seyfert galaxies was first discovered by Fitch et al. [1]. A later observation, the variability of these galaxies was confirmed by Zaitseva and Lyuty [2]. Recent space and ground-based by Dan Maoz et al. showed a change in the brightness of NGC 3516 in the X-ray region and in both the B and R ranges with a characteristic time from a few seconds to several days [3, 4]. Dan Maoz et al also notes the unique effect of delaying the onset of maxima in the optical range relatively to the X-ray maximum.

Yang et al. [5] present the results of observations of 21 new active galaxies in their work that have changed their spectral type (CL AGN). These galaxies are located at a red shift of $0.08 < z < 0.58$, which doubles the number of such objects known at present. The estimated upper transition time limits for galaxies that have changed their spectral type in this survey range from 0.9 to 13 years. The

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flux of the continuum in the optical and mid-infrared ranges becomes brighter and the spectral type changes, when moving from Sy2 to Sy1, or vice versa during the reverse transition. Changes in brightness of more than 0.2 magnitudes were detected in 15 active galaxies (CL AGN) during the transition from one type to another. The authors note the importance of understanding the physical mechanism of spectral type change (CL AGN) for understanding the evolution of the nuclei of active galaxies.

Ilic [8] presents the results of the observation of the Seyfert type I galaxy NGC 3516 in his work, which has changed its spectral type. The authors note that this active galactic nucleus has strong optical variability and changed its spectral type in the past. It has been in a low active state in the optical range since 2013 with some revival from late 2015 to early 2016 it has remained stable.

2. OBSERVATION

We carried out a photometric observation of the BVRcIc Seyfert galaxy of the first spectral type NGC 3516 at the 60-centimeter telescope of the Shamakhy Astrophysical Observatory named after N. Tusi. Photometric observation of the BVRcIc galaxy NGC 3516 was carried out within 2017-2021. The CCD photometer was concentrated at Zeiss 600 telescope for the photometric observations. The observations were carried out with a differential way using close comparison stars. Processing of the obtained photometric materials was carried out using the MAXIM DL 4 software package. Bias, dark and flat frames were obtained for calibration for this reason.

We carried out the photometric observations of Seyfert's galaxy NGC 3516 in February 2017. We chose mainly without lunar nights to observe this galaxy. Observations of the galaxy were carried out in four filters. Our observations were carried out at different times and at different intervals. As you know astronomical observations depend on weather conditions, on the visibility of the object and on the distribution of the observation time.

The standard and control stars are removed every night along with the object. The identification maps compiled as a standard and a control star compiled by Lyuty and Penston [6, 7], the stars A, C1, 2, and 3 were used for this purpose.

As can be seen from Fig.1, there is a change in brightness in the filter of B of different amplitudes. Seyfert galaxy NGC 3516 on July 3, 2017 (JD 2457938) in the filter of B was 14.29 and consequently the object gradually increased its brightness and became 13.84 magnitudes on May 16, 2018 (JD 2458255) in the same filter. The change in brightness was approximately 0.45 magnitudes in the filter of B. And then on June 15, 2018 (JD 2458285), the brightness decreased again to 14.253 magnitudes. It should be noted that until January 28, 2020 (JD

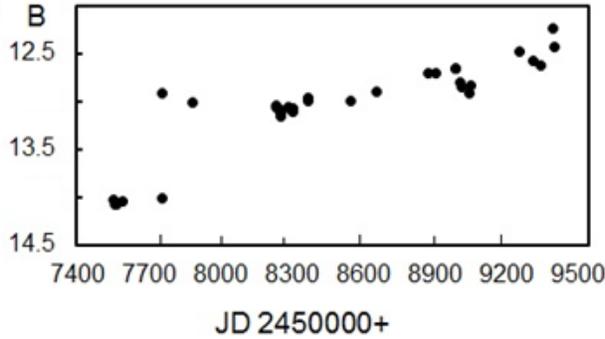


Fig. 1. The light curve in the B filter of the Seyfert galaxy NGC 3516 during the observant

2458877) it remained about the same value magnitude (14.230) in the B filter. And after that the Seyfert galaxy NGC 3516 gradually increased its brightness and on May 28, 2020 (JD 2458998), the magnitude in the filter of B became 13.91. At that time the change in brightness in the filter of B was about 0.221 magnitudes. Our further observations showed that the object weakened again and on October 19, 2020 (JD 2459142) became in the filter B=14.183 magnitudes. These photometric data obtained in filter B also confirm that the change in spectral type occurred in this Seyfert galaxy of type I NGC 3516 [9] within 2017 and 2021.

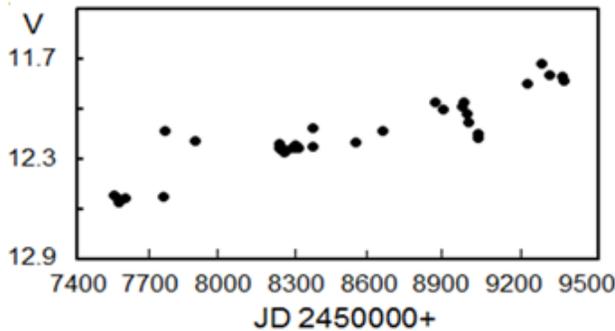


Fig. 2. The light curve of the Seyfert galaxy in the V filter constructed from observations in 2017-2021.

As can be seen from Fig. 2, the brightness also changed in the filter V during the observation period. The nature of the change in brightness in this filter is the same but naturally with smaller amplitude. The brightness of the galaxy on February 19, 2017 (JD2457804) was in the filter V = 13.271 magnitudes. And on July 3 of the same year (JD2457938) the brightness in the filter V was V = 13.372 magnitudes. The object weakened the filter in V by about 0.1 magni-

tudes. After that the object began to increase its brightness again and on May 16, 2018 (JD2458255) the brightness of the galaxy NGC 3516 became $V = 13.001$ magnitudes. The change in brightness was approximately in the filter $V=0.37$ magnitude. About a month later on July 15, 2018 (JD2459285) the object again began to weaken and was in the filter of $V = 13.291$ magnitudes. At the beginning of 2020, and more precisely on January 28, 2020 (JD2458877) the object was revived again and became $V = 13.192$. And on May 21, 2020 (JD2458991) a powerful flash occurred again and the object became brighter in the filter $V = 13.070$ magnitude. The change in brightness was approximately $V = 0.221$ magnitude. It is worth noting that the change in brightness compared to 2018 occurred with smaller amplitude. The change in the filter of V was the same as in filter B . Then the object began to weaken again and on October 19, 2020 (JD2459142) became $V = 13.283$ magnitude.

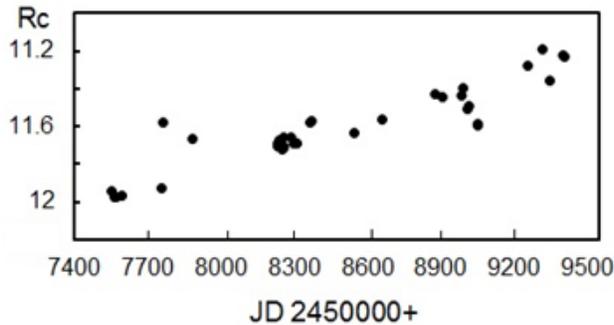


Fig. 3. The light curve of the Seyfert galaxy NGC 3516 in the Rc filter plotted from observations within 2017-2021.

As can be seen from Fig. 3, the brightness change in the Rc filter was 0.071 magnitudes from July 3, 2017 (JD 2457938) to May 16, 2018 (JD 2458255). And then the change in brightness during the observation period occurred on January 28, 2020 (JD 2458877) and on May 28, 2020 (JD 2458998). The change in brightness in the Rc filter was 0.125 magnitudes at that time. And then on October 19, 2020 (JD 2459142) the object returned to its previous state and the magnitude of the Seyfert galaxy NGC 3516 in the Rc filter became 12.534.

As can be seen from Fig. 4 in the filter Ic, the brightness of this galaxy changed during the observation period. The change in brightness occurred from July 1, 2017 (JD2457936) to May 16, 2018 (JD2458255) 0.111 magnitudes. The brightness of the object from May 28, 2020 (JD2458992) to July 20, 2020 (JD2459050) in the filter Ic is increased by 0.164 magnitudes. And then gradually the object began to weaken from July 25, 2020 (JD2459055) and on July 26, 2021 (JD2459309) it became weaker than 0.06 magnitude in the filter Ic.

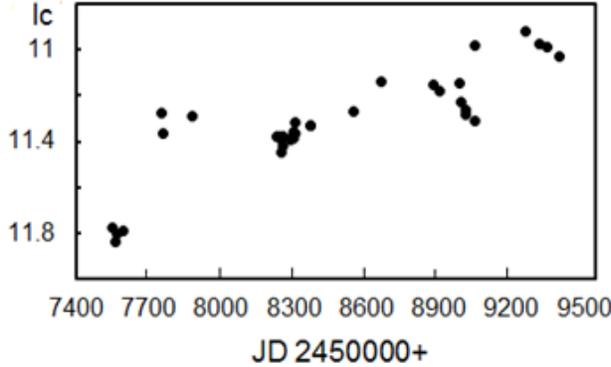


Fig. 4. The brightness curve of the Seyfert galaxy NGC 3516 in the Ic filter based on observations within 2017-2021.

Based on the results of our observations within the period 2017-2021 the change in the brightness of different amplitudes was revealed in the BVRcIc filters. The Seyfert galaxy NGC 3516 was in too active state during this period.

Constructed brightness curves based on photometric observations of the Seyfert galaxy NGC 3516 the 2017-2021 observation periods are shown in Figures 1,2,3 and 4. As can be seen from the figure within the observation period 2017-2021 the brightness of the galaxy either decreases or increases. As can be seen from Fig. 1 in filter B the largest change in brightness was detected within the observation period from July 18, 2017 to May 16, 2018. The amplitude of the change in brightness in filter B was approximately $\sim 0.45 \pm (0.005)$ magnitudes. After that the brightness of the galaxy decreased. And during the observation period from January 28, 2020, the object began to revive again and on May 28, 2020 it became brighter again and the change in brightness in filter B was $\sim 0.343 \pm (0.005)$ magnitudes. According to the spectral observations, the Seyfert galaxy NGC 3516 experienced a change in spectral type during the same period [9]. The same process of changing type occurred in 2018. It should be noted that the results of the photometric observations confirm the change in the spectral type of the Seyfert galaxy NGC 3516 obtained from spectral observations.

Thus our photometric observations of BVRc and Ic show that variability occurred in the Seyfert galaxy NGC 3516 and this fact confirms the change of spectral type detected as a result of spectral observations.

3. RESULTS

Our results from the photometric observations within 2017-2021 confirm the change of spectral type obtained from spectral observations within 2016-2020.

Photometric BVRlc observations also show that the active physical processes occurred in the galaxy NGC 3516 within the period 2017-2021.

The largest brightness change within the 2017-2021 observation period in the BV Rc and Ic filters was $0.36 \pm (0.005)$; $0.28 \pm (0.005)$; $0.07 \pm (0.003)$ and $0.04 \pm (0.004)$ respectively.

The reason for the photometric variability of the Seyfert galaxy NGC 3516 may be the change in the rate of accretion to the galactic nucleus.

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