PHOTOMETRIC AND SPECTRAL STUDIES OF ACTIVE-NUCLEUS GALAXIES IN SHAMAKHY ASTROPHYSICAL OBSERVATORY FOR THE PERIOD 1987-2019

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Introduction

Study of photometric and spectral variability is an effective method for diagnosing physical processes occurring in the accreting compact supermassive objects, which are the majority of the nucleus of active galactic (AGN). Characteristic time of this variability shows small sizes of regions emitting optical continuum and broad emission lines. Investigation of the photometric and spectral variability is necessary to explain the structure of active nuclei, without which it is impossible to get close to the solution of the problem of the central energetic source. To refine AGN models it is very important to have information on the nature of their variability. In the model of a supermassive black hole with an accretion disk, both periodic and chaotic brightness variability of galactic nuclei could be expected during the same night. Knowing the properties of optical variability allows us to limit the possible types of models. There are two most popular models of central energetic source: accreting black hole and non-collapsed magneto-plasma body. Observations of a strict periodic brightness variability of galaxies continuing during several cycles or absence of strict periodicity might be a weighty argument in favor of one of the two above-mentioned concepts. Researches of nuclei of active galaxies changing spectral and photometric characteristics and spectral type in a short-term period because of significant variations of luminosity are certainly actual since they give us important information for understanding the geometry, physical nature and evolution of the nuclei of active galaxies. The term "nucleus of active galaxies" (AGN) shows that the observed properties of the central regions of galaxies could not be explained only by the formation and evolution processes of the stellar population of galaxies.

The spectrum of the galaxy consists of the electromagnetic emission of the whole its constituent objects. The spectrum of the galaxy has two local maxima. The emission source of galaxies - mainly are stars, the maximum emission intensity of most of them is in the optical range (first maximum). As usual, there is much dust in galaxies, which absorbs radiation in the optical range and re-radiate it in the infrared diapason. Because of this, the second maximum falls in the IR regions of the spectrum.

Galaxies with strong emission spectra in nuclei, as a separate class of objects, for the first time were determined by the American astrophysicist S. Seyfert. In 1943, he published a study of 12 such unusual galaxies, later these galaxies named after him - Seyfert galaxies. A serious interest in these objects began only in the late 1950s of the last century. Historically, the study of active nuclei galaxies at the Shamakhy Astrophysical Observatory named after N. Tusi, of the Azerbaijan National Academy of Sciences (ShAO ANAS) was started by N.A. Huseynov in 1987. A number of works were carried out in this direction and very important scientific results were obtained at ShAO ANAS.

Photometric and spectral characteristics of the variability of quasar 3C 273

Photometric UBVR observations carried out on April 19-20, 1988 of the quasar 3C 273 also showed a brightness change over 2.8 hours. Photometric UBVR observations were carried out using an electroctrophotometer operating in the photon counting mode, installed on the 60-cm reflector of ANAS SHAO. The amplitude of the brightness variability in the UBVR filters for one night was 0.23m; 0.10m; 0.14m and 0.13m, respectively [1].

Observations with the space telescope were carried out in 1978-1994. 253 ultraviolet (UV) spectra were taken from the IUE database archive. 142 from these are SWP spectra, covering the range of 1000-2000 Å, the rest of the LWP spectra cover the range of 2000-3300 Å. For SWP spectra, the dispersion is 1.515 Å/mm, and the resolution is 6 Å/mm. It should be noted that the observations were carried out for 16 years and in different seasons of the year. Sometimes in the same night for several hours with interruptions, 3-4 spectra of the quasar 3C 273 were obtained. Using these spectral data, we measured the flux in the continuous spectrum, and also estimated the intensity (flux) in different emission lines (OVI (1033 Å), Lα (1216 Å), SiIV+OIV 1399 Å, C IV (1549 Å) [2].

One of the key questions facing astrophysicists is the question of the energy source of the activity of compact objects, the mechanism of their energy release and collimation of the outflowing matter. According to modern concepts, massive black holes are present in most galaxies and remain active as long as a sufficient amount of matter falls on them. This limits the time of their active life. It is usually assumed that the accretion of matter is disk in nature.

The nature of the change in the flux in the continuous spectrum and the intensity in various lines were analyzed. A high degree of correlation is observed between the fluxes in the 1300Å and 1650Å continuous spectrum. The correlation is r = 96.8%. The flux in the continuous spectrum at 1650 Å and the flux in the C IV line at 1550 Å show an inverse correlation (r = -61.8). The flux changes in the OVI, L_α, Si IV + OIV and CIV lines have been studied and it has been established that the variability in the continuous spectrum and in the lines is chaotic. This gives us a reason to assume that the mechanisms of generation of these emissions are different and not related to each other [3].

In conclusion, we present the main conclusions we obtained in this work:

1. Obtained in 1978-1994 UV spectra of quasar 3C 273 show chaotic variability of the flux in the continuous spectrum and in different lines. Short-term and long-term changes in the spectrum were found.
2. For quasar 3C 273, fluxes in the continuous spectrum in the 1300 Å and 1650 Å bands show a very high degree of correlation: r = 96.8%. This indicates that the fluxes of radiation in the continuum of relatively close regions are formed under the action of the same physical processes.
3. The fluxes in the continuous spectrum and in emission lines (for example, in the C IV 1550 Å line) show an inverse correlation with each other: r = - 61.8%. This may indicate that the mechanism for the formation of a continuous spectrum and different lines is different.
4. The change in the flux amplitude in the continuous spectrum is more than 2.5 times of the change in the flux amplitude in the lines [2,3].

Spectral and photometric study of the first type seyfert galaxy NGC 3516

Galaxies with active nuclei are subdivided into Seyfert galaxies, quasars, lacertids, and radio galaxies. According to modern concepts, the activity of galactic nuclei is explained by the presence of supermassive black holes in their nuclei, onto which galactic gas and stars are accreted. And the difference in the types of galaxies with active nuclei is explained by the difference in the angle of inclination of the plane of the galaxy in relation to the observer.

Observations of the nucleus of the Seyfert type-1 galaxy NGC 3516 were carried out in 1989-1994 with the Zeiss-600 telescope of the Azerbaijan National Academy of Sciences. Fast photometric observations were carried out in a differential way, using close comparison stars, with an aperture of 27″ and with a UBVR electrophotometer operating in the photon counting mode. FEU-79 was used as a radiation detector [4].

A fast photometry of the nucleus of the Seyfert type 1 galaxy NGC 3516 was carried out. The observation was carried out with the Zeiss-600 telescope of ShAO ANAS, with an aperture of 27". The brightness of the galaxy NGC 3516, according to observations on May 9/10, 1989, changes during one night with an amplitude of 0m.09 ± (0m.012), 0.m05 ± (0.m005), 0m.07 ± (0m.009) and 0.m05 ± (0.m005) in the UBVR filters, respectively. The duration of observations was 3 hours 10 minutes [5].

On December 16/17, 1993, the UBVR photometry of the nucleus of the same galaxy was carried out for 1 hour 30 minutes. No brightness changes with an amplitude exceeding 0m.02 were found. The brightness changes on December 22/23, 1993 within 2 hours 46 minutes were found only in filter B and amounted to 0m, 04 ± (0m, 009) [6].

On January 7/8, 1994, UBVR photometry of the nucleus of the galaxy NGC 3516 was carried out for 2 hours 10 minutes. The brightness changes of NGC 3516 were 0m, 08 ± (0m, 012); 0m, 07 ± (0m, 008); 0m, 04 ± (0m, 009); 0m, 05 ± (0m, 005) in UBVR filters, respectively. And that night, a unique delay effect was observed [7].

The nucleus of the galaxy NGC 3516 was observed on January 11/12, 1994 for 2 hours 27 minutes. The brightness changes were 0m, 06 ± (0m, 011); 0m, 05 ± (0m, 009); 0m, 04 ± (0m, 008) in UBV filters, respectively. And in the R filter, no change in brightness was found. On January 18/19, 1994, the UBVR photometry of the nucleus of the galaxy NGC 3516 was carried out for 1 hour 55 minutes, the brightness changes of which were 0m, 04 ± (0m, 011) and 0m, 06 ± (0m, 008) in the UB filters, respectively. No changes in brightness were found in VR filters [8].

The results of the above observations allow one to assume that a flare has been detected in the core of the Seyfert galaxy NGC 3516, with a characteristic time of about 100-120 minutes. The brightness changes are not observed every night and are chaotic [6, 7, 9].

Since the speed of light propagation is limited, the size of the region responsible for this variability can be determined from the characteristic flash time. Thus, the brightness variability is the result of a certain physical process that covers the entire nuclear region of the galaxy

$R = C \times T = 3 \times 10^{10}$ cm/sec $\times$ 7,6 $\times 10^{3}$ sec = 0,228 $\times 10^{15}$ cm

The size of the domain, which is responsible for the brightness change, is determined from the characteristic variability time and is 0.228 x 1015 cm [10].

In addition, observations in four filters have revealed a unique delay effect in brightness changes, the maxima of which come from U to R with a delay of about 30 minutes. An effect of this nature was observed from observations of NGC 3516 on May 9/10, 1989, and January 7/8, 1994. The variability on May 9/10 was 0m.09 ± (0m.012) and 0.m05 ± (0.m005) and 0m.07 ± (0m.009) and 0.m05 ± (0.m005) in the UBVR filters, respectively. The brightness changes of the core of NGC 3516 on January 7/8, 1994 was 0m, 08 ± (0m, 012); 0m, 07 ± (0m, 008); 0m, 04 ± (0m, 009); 0m, 05 ± (0m, 005) in the UBVR filters, respectively [7].

It should be noted that, in UBVR filters, the brightness of the galaxy NGC 3516 from 1989 to 1994 is increased by about 0.6m-1m. Considering the fact that the possibility of observing this object from one geographic point does not allow covering the time range of more than three to four hours, it is impossible to confidently note the nature of the variability. It would be desirable to carry out coordinated observations in different observatories in longitudes [11].

It was found that the Seyfert galaxies of the first type NGC4151 and NGC 3516 show rapid variability (1,3), while the SyG of the second type NGC 1068 does not show such variability [6]. It was found for the first time that the amplitude of a burst of rapid variability in the quasar 3C 273 is twice that in the Seyfert type I galaxies NGC 3516 and NGC 4151 [7].

The observations were carried out in 1978-1994. 64 ultraviolet (UV) spectra were taken from the IUE database archive. SWP spectra cover the region 1000-2000 Å. For SWP spectra, the dispersion is 1.515 Å/mm, and the resolution is 6 Å/mm

We measured the flux in the continuous spectrum in two bands at 1300 Å and 1650 Å. Also the intensity in the various emission lines. Basically, we have considered only emission lines in the UV part of the spectrum. We are mainly interested in the nature of the change in intensity in different spectral ranges, since studying the intensity makes it possible to construct a photoionization model of the surrounding gas cloud. According to this model, the surrounding gas cloud is ionized by radiation coming from a central source. For this reason, long-wavelength radiation also occurs.

In conclusion, we present the main conclusions we obtained for the Seyfert galaxy of the first type, NGC 3516.

1. A flare was discovered in the Seyfert galaxy of the first type NGC 3516 during the same night, with a characteristic time of 100-120 minutes. According to observations on May 9/10, 1989, the brightness of the galaxy changes during one night with an amplitude of 0m.09 ± (0m.012); 0.m05 ± (0.m005); 0m.07 ± (0m.009) and 0.m05 ± (0.m005) in UBVR filters, respectively. On January 7/8, 1994, the brightness changes were 0m, 08 ± (0m, 012); 0m, 07 ± (0m, 008); 0m, 04 ± (0m, 009); 0m, 05 ± (0m, 005) in UBVR filters, respectively. [7, 8, 9]
2. A unique delay effect is observed, in other words, brightness changes, the maxima of which come from U to R with a delay of approximately 30 minutes. The delay of the long-wavelength radiation of the continuum with respect to the short-wavelength observed at the ShAO and foreign observatories may indicate that the glow of most AGNs is caused by strong friction and heating of the gas in the accretion disk. But there is still no reliable proof of this [11, 12, 13].
3. For the Seyfert galaxy of the first type NGC 3516, the size of the region, which is responsible for the brightness change, is determined from the characteristic variability time and is 0.228 x 1015 cm [10].
4. The brightness variation of the Seyfert type 1 galaxy NGC 3516 is chaotic. Both active and passive states of the nucleus are observed [14].
5. According to UV observations on 1978-1994 of the Seyfert galaxy of the first type, NGC 3516, a chaotic change in the flux of the continuous spectrum, as well as the intensity of the emission line, was found. There are fast (weekly), average (monthly) and long-term (annual) components of the change in the UV spectrum of this galaxy;
6. In 1980 in NGC 3516 the intensity of various lines was at the maximum, but this year the flux at the level of the continuous spectrum is not observed at the minimum. The reason for this phenomenon may be that the emission line is formed due to a non-thermal mechanism, and the continuous spectrum is formed due to a thermal mechanism;
7. In the continuous spectrum at different wavelengths (1300-1650 Å), fluxes at a very high level (r = 98%) correlate with each other [14].

Spectral and photometric study of the seyfert galaxy NGC 2617

In the unification model, two main types of AGN are postulated, with wide emission lines (type I) and only with narrow lines (type II), which are the same type of objects, the appearance of which depends on the visibility to the observer. Type I AGNs have very broad emission lines and a higher level of continuous emission, while type II AGNs lack broad lines, have only very narrow emission lines and a weaker continuum. The idea behind the unification scheme is that the central black hole is surrounded by a "dark torus" of gas and dust.

Thus, if broad emission lines are created in a region close to the central black hole, and narrow lines are emitted at a more distant distance outside the torus, then broad lines may be hidden depending on the angle at which the AGN is seen. The best evidence for this scenario is the spectropolarimetric observations of some type II AGNs, in which broad emission lines are visible in polarized light, which can happen if the broad line region is indeed hidden and the light is reflected from the torus towards the observer.

How supermassive black holes form in these galaxies is still a mystery. The fact is that they are visible even in the early Universe, hundreds of millions of years after the Big Bang, and already have a large mass, although according to calculations they should not have time to gain it with such a short history of existence [18].

Thus, the abrupt change in the Seyfert spectral type due to flares observed in some AGNs, including NGC 2617, can provide us with very important and valuable information for understanding the geometry, physical nature and evolution of the nuclei of active galaxies.

We also carried out spectral and photometric monitoring of the Seyfert galaxy NGC 2617 in January 2016 in order to find out, how three years after an intense monitoring campaign in 2013, Shappee et al. changed its spectral type back or remains a Seyfert type 1 galaxy (Sy 1).

Our observations covered the region from IR (JHK) and optical (BVRcIc) photometry and spectroscopy. In addition, we used filter-free optical monitoring of the robotic International MASTER network from 2010 to 2016. We found that the nucleus of NGC2617 remains in a high state so far and can still be classified as type-Sy 1. Observations in the optical and infrared (IR) ranges showed that NGC 2617 AGN activity continues and that in 2016 in April-June he underwent another series of outbreaks. These flares are comparable in level to those when NGC 2617 was observed by Shappee et al. in 2013. We then began observing in soft X-ray and ultraviolet light with the Swift spacecraft. These observations began in 2016 on May 17, and continued until 2016 on June 23 [15].

Our problem was to examine this object to see if it returned to its normal state of low activity again? We managed to combine the efforts of colleagues from a number of observatories and countries. We were able to show that the object is still in an active state and has not returned to its previous spectral type. We found several bright flares (comparable to those observed in 2013), which were accompanied by spectral variability. According to IR observations obtained with the new 2.5 SAI telescope, it was found that the variability delay in the *K* filter increased by about a factor of 2, which may be due to the partial sublimation of dust over the past three years [19].

We obtained optical spectra in the range of 4100-7000 Å using a 2×2 prism spectrograph and a 4K CCD (spectral resolution 3-7 Å) on a 2-m telescope of ShAO at four nights in 2016 on February 2 and 4, March 4 and April 9. From our spectra obtained in the first half of 2016, it can be seen that the Seyfert galaxy NGC 2617 can be classified without any doubt as an NGC of type Sy 1. In our spectra one can see the displaced component of the emission in the red wing Hβ with a relative velocity of about + 2500 km/sec, which is not visible in the spectra obtained by Shappee et al. in 2013. We were unable to verify that this new component is also present in the Hα profile due to the low resolution of the prism spectrograph at long wavelengths. This component in the red region cannot be reliably identified in the Hγ profile, since there is strong emission in the forbidden line [O III] λ 4363 [19].

Optical and near-infrared photometry, optical spectroscopy and soft X-ray and UV monitoring of the nucleus of the active galaxy NGC 2617 with a changing appearance show that it still looks like a Seyfert type 1 galaxy. In 2016, NGC 2617 revived again to a level of activity close to the level of 2013. We find variations in all passbands, both in intensities and in broad Balmer line profiles. A new shifted emission peak appeared in the region of the Hβ lines. The change in the X-ray region correlates very well with the UV region and may be delayed by about ~ 2-3 days. The K band is delayed relative to the J band by about 21.5 ± 2.5 days and the total delay in the B + J filters is about ~ 25 days. The delay in filter J from filter B is approximately 3 days. This may be due to the fact that the change in the J-band occurs in the outer part of the accretion disk, and the change in the K-band is due to the thermal re-ejection of dust. We assume that the changes in spectral type are the result of an increase in the central luminosity, causing the sublimation of the innermost dust region in the biconical outflow field. We will briefly discuss various other possible causes that could explain the dramatic spectral-type changes in the Seyfert galaxy NGC 2617 [16].

Having changed its spectral type, the Seyfert galaxy NGC 2617 had approximately the same brightness in 2012 and in 2016 and in February 2017, and in 2016 it had a type 1 Sy spectrum, so we assume that a sharp change in the type of NGC 2617 was not associated with the increase in brightness observed in 2013, occurred between October 2010 and October 2012 [17, 19].

CCD photometry on the 50-centimeter telescope AZT-5 at the Crimean station of the Sternberg Astronomical Institute Moscow State University (SAI) conducted on May 7 and 9, 2016 showed that NGC 2617 had B = 14.71 in the filter in a 10-second aperture. This is about 0.3 stellar magnitudes brighter than April 22 of the same year [15].

CCD photometry performed without a filter with a 15 second (8-pixel) aperture of the Global International Robot Network MASTER on May 11, 2016 confirms that NGC 2617 continues to remain bright and continues to change brilliance over time. It is brighter than April

22 by about 0.1 magnitude. The measurements were carried out using the MAXIM DL package with an aperture of 10 seconds. Seyfert galaxy NGC 2617 became brighter in the filter was B = 15.1, became B = 14.8 in March, and then faded to B = 14.99 over the next three weeks. The amplitude of the V-band brightness variation was approximately half of the B-band variability [17].

We also carried out JHK-photometry with the new 2.5-meter telescope of the Caucasian Mountain Observatory of the SAI using the ASTRONIRCAM instrument operating in the JHK bands from January to April 2016. The photographs show the light curve in the IR region with a 5 second aperture. The performed cross-correlation analysis shows that changes in the K-band relative to the J-band are lagged by 18 ± 2 days. This is roughly double that obtained from Shappee et al., 2013 IR data. If the delays obtained from observations are real, then this can be explained by the sublimation of a part of the dust around the core over the past three years [19].

All NGC 2617 data converted to International Johnson-Cousin value. We measured the background in a circular radius of 35-45 seconds. Light curves in BVRcIc fillers are shown in Fig. 2. The magnitudes correspond to an aperture radius of 5 seconds. From the figure, you can see how NGC 2617 became brighter by about 0.3 magnitudes in the filter during the month of March, and then became fainter by 0.1 magnitudes in mid-April. It became brighter again at the end of April and peaked at about 14.6 in the B filter on May 19, 2016. Another maximum of such values was reached on June 15, 2016. The amplitude of the changes in the V filter was approximately half the amplitude in the B filter. Variations in R_c and I_c were synchronized with the B-band variations, but still with smaller amplitudes [17].

The SWIFT telescope observed NGC 2617 both when counting photons and in time modes in the window, depending on its brightness. The spectra have been scaled down using online tools provided by the UK SWIFT Science Data Center; The resulting spectra were grouped to have at least one count per bin and were set in the 0.3-10 keV range with the XSPEC software package using Cash statistics.

The Swift UV and Optical Space Telescope observed in parallel with the XRT telescope, which allows for broadband coverage from optical to X-ray range. During our program, observations were made with a filter of the day. Image analysis was performed according to the procedure described on the Swift Science website of the British Data Science Center. Photometry was carried out using the uvotsource procedure with initial apertures of radius of 5 and 10 seconds for the background for all filters.

The previous X-ray flux, variations in UVW1 and in filter B in combination with filter-free MASTER optical data (2010-2015) is very well consistent. The amplitude of the gloss change is the largest for X-rays and decreases as wavelength increases.

We estimated the delays between changes in the continuum in different bands using two independent methods: MCCF, a modification of traditional cross-correlation methods) and Bayesian analysis using the JAVELIN software [19].

Seyfert galaxy NGC 2617 is a typical example of a JAG with a changing appearance. It was observed that between 2003 and 2013 there were significant changes in brightness and spectral type from Sy 1.8 to Sy 1. In January 2016, we started spectroscopic and photometric (IR-JHK and optical BVRI) monitoring of NGC 2617 to make sure that it is still in state Sy 1. In 2016 and 2017, NGC 2617 revived again to near-2013 activity levels. However, from early April 2017 to late May 2018, the object had a very low brightness level and there was little change. In December 2017, according to observations of the Swift Space Telescope, the flux in the X-ray region (X-ray) was the lowest, since when monitoring began in 1982 with UVW1 = 15.16 ± 0.03, B = 15.60 ± 0.03 (Swift). It should be noted that a similar deep minimum was observed in April-May 2018 according to optical data. Our new optical spectra, obtained in April-May 2018, showed very low intensity of the broad H_β line. We have reported a new outbreak detected by MASTER (Global Robotic Network) data. This outbreak came after a very long low state during 2017. In early June 2018, NGC 2617 became brighter again and now has a magnitude in the filter B = 14m, 9 ± 0m, 05 [20].

The unification model of ANG, which explains the variety of types only by different orientations to the observer, is very popular, but it has a number of problems and, in particular, is not able to explain cases of rapid changes of the spectral type. We assumed that such changes are not exceptions, but occur regularly in all RAG variables. The differences in the types of RAG are undoubtedly associated with different levels of absorption in the vicinity of the nuclear region, but it is obvious that the change in the spectral type cannot be explained by the rapid changes in the orientation of the galaxy to the observer. The example of our galaxy can be convinced of this. Our Galaxy around its axis at a speed of 220 km/sec makes a complete revolution in 230 million years. From this statement it can be seen that the change in the orientation of the galaxy to the observer occurs over a very long period of time and cannot explain the fast, that is, over 5 - 10 years, changes in the spectral type of active galaxies.

Taking this into account, we assumed that the absorption changes due to changes in the accretion rate and variations in the luminosity of the central source in the ANG, which leads to changes in the concentration of dust in clouds along the line of sight. Earlier, a model of the conical outflow of dust clouds was proposed, which allows one to naturally explain the results of the independence of IR delays on the wavelength, as well as cases of changes in the spectral type of ANG. This hypothesis has been published and discussed by us at a number of international conferences, has independent observational confirmation, but needs further verification [19].

We consider it more probable that changes in the spectral type of ANG are a consequence of normal processes for Seyfert galaxies. It has also been argued for a long time that the type of ANG depends on the accretion rate and, therefore, changes in the spectral type arise due to changes in the luminosity of the central engine. Our observations from X-ray to infrared regions of the Seyfert galaxy NGC 2617 support this picture. In order to explain the changes in the optical attenuation of ANG and the associated changes in the X-ray spectra, it has been proposed that the damping material has an inhomogeneous distribution.

We have shown using spectral and multiwave photometric observations that the Seyfert galaxy NGC 2617 continues to be in an active state and, apparently, while it is of the spectral type Sy 1. Remaining in an active state for a long time and the occurring short-term variability are not always consistent with a change spectral type due to the ongoing tidal disruption in NGC 2617. We assume that the spectral type change was the result of increased luminosity causing dust to sublimate in the interior of the biconical dust outflow. This leads to a much more direct look at the central regions of the galaxy.

For the first time, we discovered the presence of a variable emission component in the Hβ line profile in the Seyfert galaxy NGC 2617 and noted that similar features are characteristic of other CL AGNs [19, 21].

We assume that the sharp change in the spectral type of the Seyfert galaxy NGC 2617 was not associated with the increase in brightness observed in 2013, but it is likely that the change in the spectral type occurred a little earlier, that is, between October 2010 and February 2012. This result is confirmed by observations of the international robotic network MASTER carried out in the period 2010-2016.

We determined the time delay in the K band (2.2 μm) relative to the optical variability in NGC 2617 in 2016 was about 25 days, which coincides with the estimate of the radius at which dust sublimation should occur. According to Shappee et al in 2013, the delay was about 10 days. We analyzed the data obtained by Shappee et.al. and came to the conclusion that these data do not allow, unfortunately, to reliably determine the delay. It is possible that changes in the magnitude of the delay have occurred, but the available data do not allow it to be unambiguously determined. [19, 21].

Spectral and photometrıc study of the seyfert galaxy NGC4151

We plotted the historical light curve for the Seyfert type 1 galaxy NGC 4151 for the period 1906-2016. Using the Fourier algorithm (CLEAN algorithm), we found a periodic component of ~ 16 years in the 110-year light curve. 40 years ago, the same period was initially obtained from Odessa photometric data. This "period" observed on the light curve was then independently derived from spectral variability and is interpreted as the case of a supermassive binary black hole. We interpret these periods as some dynamic accretion times.

Relationship between the trial period P and its amplitude (in magnitudes) obtained by the CLEAN method. The usual period of about 16 years, which was first discovered 40 years ago by Oknyansky, is still the same period in variability over the past 110 years. The new CCD photoelectrical data were obtained with a 0.6-m telescope at the Shan of ANAS and a 1.0-m telescope at the Weihai Observatory of Shandong University in Shandong province. We have also added 29 points from Schnülle et al reduced from z to our system in B [22].

Historical light curve plotted by us from observations for the historical period 1906-2016. On the 110-year light curve, we can see various variable components: 1 - a fast component, variability with a characteristic time of about tens of days, 2 - a slow component, changes with a characteristic time of about several years, 3 - a very slow component with a time of about tens of years.

To search for the periodic component, the Fourier analysis algorithm (CLEAN) was applied; to the data obtained in the period from 1906 to 2016 (smoothed steps of 100 days), we found a periodic component of about P ~ 15.7 years in the 110-year light curve. This "period" observed in the light curve was then found independently and in spectral variability and was interpreted as the case of a supermassive binary black hole [22].

We present the historical light curve for the Seyfert type 1 galaxy NGC 4151, which changed its spectral type in 1984 during 1906-2016 which is the longest known light curve among the variable Seyfert galaxies. The interval between 1906-1966 is mainly represented by the obtained photographic observations, which were obtained in Moscow, Odessa, Harvard and Stewart on photographic plates, which are preserved in archival data. All these data can be combined together and reduced to the same system as the photoelectric data in the B filter. The calculations were carried out only using magnitudes obtained from the Odessa Observatory, since these observations overlap with photoelectric and other photographic data. Pacholczyk values require very large scale and zero corrections before plotting them along with other photometric data. The historical light curve shows various components in variability over 110 years. A very high and long-term active state in the Seyfert galaxy of the first type, NGC 4151, was during 1987-1998 and occurred only once in 110 years. We confirm the presence of a regular component, with a period of about 16 years. We interpret these cyclical periods for the Seyfert type 1 galaxy NGC 4151 as a typical dynamic accretion time [22].

Determination of the distance to NGC 4151 based on spectral and photometric observations of the supernova SN 2018aoq

The supernova SN II-P 2018aoq, which exploded in the Seyfert galaxy NGC 4151, after the explosion from 2 to 100 days photometric and from 11 -71 days, spectral observations of this unique object were carried out. The distance to this object is known with poor accuracy, which interferes with effective calibration. Estimates of the distance to NGC4151, published in recent years, range from 4 to 29 Mpc. Significant peculiar velocities make estimates based on red mixing very uncertain and therefore, requires distance determination based on other methods. We have determined the distance using two methods. The II-P supernova SN 2018aoq in the Seyfert galaxy NGC4151 presents a unique new opportunity to obtain an independent distance to the galaxy. We used our photometric UBV RI CCD observations (60-cm and 50-cm telescopes of the Crimean observatory of the GAISH; 70-cm and 20-cm of the Moscow observatory of the GAISH; 1-m telescope of the Simeiz observatory INASAN; 60-cm telescope of the SHAO) and spectral observations (2-m telescope of ShAO). Using the EPM (Expanding Photosphere Method) method, we found the distance D=20.0±1.6 Mps. And using the standard candle method, we found 16.6±1.1 Mps. It should be noted that determining the distances to galaxies is of very great scientific importance. Since this makes it possible to construct distance scales in the Universe, a very important role will play a role in clarifying the Hubble constant and the age of the Universe. Other dynamic methods can be calibrated from these measurements [23].

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