

TOTAL AND GAS FLOW ACTIVITY OF THE SEYFERT GALAXY NGC3227 NUCLEUS FOR ITS DIFFERENT EVOLUTIONARY EPOCHS

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ABSTRACT. A comparative analysis of time variations of spectral characteristics of the Seyfert galaxy NGC 3227 nucleus: equivalent widths ($EW \lambda$), relative intensities, the width of the Balmer line profiles was carried out. Spectral data obtained in April 2009 with the 1.5-m Russian-Turkish telescope (RTT-150) and data published in the literature were used. Results of the comparative analysis showed the weakening of total activity and, consequently, gas flow activity of the galaxy nucleus in the time interval of more than 30 years.

Key words: Galaxies: Seyfert – individual: NGC 3227.

1. Introduction

The galaxy NGC 3227 has an active Seyfert nucleus (AGN). The long-term studies of AGN, carried out across the electromagnetic spectrum, including optical, provide with rich material for understanding physical processes that take place in their nuclei. In particular, Rubin and Ford [1], Rosenblatt et al. [2,3], Wing, Peterson et al. [4] I.I. Pronik [5], I.F. Bikmaev, I.I. Pronik, L.M. Sharipova [6] studied these problems. I.I. Pronik, L.P. Metik [7,8] obtained the evidence of the 3-day flare in gas of the Broad line region in the period of maximum brightness of the Seyfert galaxy NGC 3227 nucleus in January 1977. A number of works were devoted to the study of variability of the Balmer line profiles in the spectrum of the galaxy NGC 3227 nucleus and its gas flow activity. Spectral data obtained with the 6-m telescope of the Special Astrophysical Observatory in January 1977, data obtained at the Crimean Astrophysical Observatory in March 1977, as well as data acquired with the Russian-Turkish Telescope (RTT-150) in April 2009 formed the basis of our investigations. Variations of spectral characteristics of the radiation from the galaxy NGC 3227 nucleus were analyzed. Results of our studies are presented below.

2. Comparative analysis of spectral characteristics

2.1 Variation of relative intensities of the Balmer lines with time

The investigations of variability of relative intensities of the Balmer emission lines in the spectrum of the galaxy NGC 3227 nucleus have been carried out at the Crimean Astrophysical Observatory over 40 years. In particular, I.I. Pronik [9] studied the nature of variability of relative intensities of the emission lines and obtained evidences of heterogeneity of physical conditions in the gaseous environment of the galaxy NGC 3227 nucleus. In this paper we have traced variations of relative intensities of the emission lines over the period 1977 to 2009. Relative intensities of the Balmer lines $I_{H\gamma} / I_{H\beta}$, $I_{H\alpha} / I_{H\beta}$ in 1977 were taken from [9]. Relative intensities of the same lines in 2009 were estimated on the spectral data obtained with the 1.5-m Russian-Turkish telescope (RTT-150). Results of the comparative analysis of variations of relative intensities of the Balmer and forbidden lines are given in Tables 1 and 2.

These two tables show a decrease of relative intensities of both Balmer and forbidden lines in the interval of time from 1977 to 2009. The decrease factor of relative intensities of the Balmer lines was 2 and 2.5, respectively. The decrease of relative intensities of the forbidden lines was rather significant (about 3 times), except the relative intensity of the [OIII] 5007Å line (roughly about 6%).

2.2. Comparison of equivalent widths of the Balmer lines

The equivalent widths ($EW\lambda$) of the Balmer lines were that spectral characteristics which may vary over the time. Investigations of these possible variations were carried out in our work. Table 3 shows $EW\lambda$ values of the hydrogen lines $H\delta$, $H\gamma$, $H\beta$, $H\alpha$ for two epochs of the galaxy nucleus activity. Data presented in the table show a decrease of equivalent widths of the hydrogen lines by a factor of 2.6, 2.3, 1.7 and 1.5, respectively.

Table 1. Comparison of relative intensities of the hydrogen lines

Date	04. 2009	03. 1977	04. 2009	03. 1977
	IH γ / IH β		IH α / IH β	
	0.24	0.48	2.77	6.92
	0.22		2.84	
	0.22		2.84	

Table 2. Comparison of relative intensities of the forbidden lines

Date	04. 2009	03. 1977	04. 2009	03. 1977	04. 2009	03. 1977
	I[OIII]5007Å/ IH β		I[OI]6300Å/ IH β		I[SII]6716Å/ IH β	
	3.11	2.98	0.26	0.7	0.36	1.1
	3.18		0.25		0.36	
	3.3		0.27		0.39	

Table 3. Variations of equivalent widths of the hydrogen lines H δ , H γ , H β , H α

Date	01.1977	04.2009	01.1977	04.2009	01.1977	04.2009	01.1977	04.2009
	EWH δ		EWH γ		EWH β		EWH α	
	29.3	11.2	47.3	20.7	97.9	57.1	412	301
	25.2	12.5	44.9	22.4	66.2	54.5	420	302
	27.1	12.6	45.0	20.9	67.9	53.9	446	296
	34.3		44.6			70.2	450	

2.3 Widths of the hydrogen line profiles

The width variations of the H γ , H β , H α hydrogen line profiles have been traced in the time interval of more than 30 years. Table 5 shows widths of the Balmer line profiles at the level 0.25 of peak brightness (0.25I_{max}).

Table 4. Widths of the hydrogen line profiles

Date	January 1977	April 2009
	0.25I _{max} , km / sec	0.25I _{max} , km / sec
H γ	10404 ±449	4500 ±180
H β	6107 ±293	3816 ±107
H α	4291±181	3367 ± 37

Table 4 shows that the width decreasing of the H γ , H β , H α line profiles at the level 0.25I_{max} in the time interval of more than 30 years was on the factor 2.3, 1.6, 1.3, respectively.

The comparative analysis showed a significant decrease of spectral characteristics over the time. This fact is the evidence of weakening the total activity of the galaxy nucleus. For this reason, it was of interest to follow the variation of hydrogen line profiles for determining the presence or absence of their components. Such

components can be the pointers of gas flow activity of the galaxy nucleus.

3. Multi-component hydrogen line profiles and gas flow activity of the nucleus of NGC 3227

The multi-component structure of the H β line profile was first indicated by Rubin and Ford [1]. The authors studied the H β line profile in the epoch of deep minimum of brightness of the galaxy NGC 3227 nucleus. In our paper results of the comparative analysis of time variations of forms of the hydrogen line profiles are presented. The spectral data obtained with the 1.5-m Russian-Turkish telescope, as well as data published in the previous papers [5-8] were used in our investigations. The example of variable H γ , H β line profiles for two epochs (1977 and 2009) is shown in Fig. 1 and Fig. 2. Components noted in [1] are labeled by numbers 1 - 5 in these figures. In the epoch of maximum brightness of the galaxy nucleus in January 1977 the blue wing of the H γ , H β line profiles is seen to contain "blue" emission component (in our notation – component 6). In 2009 component 6 is absent in the H γ , H β line profiles. Both figures show the scale rule of the estimation of the hydrogen lines gas velocity. It is 5000 km / sec.

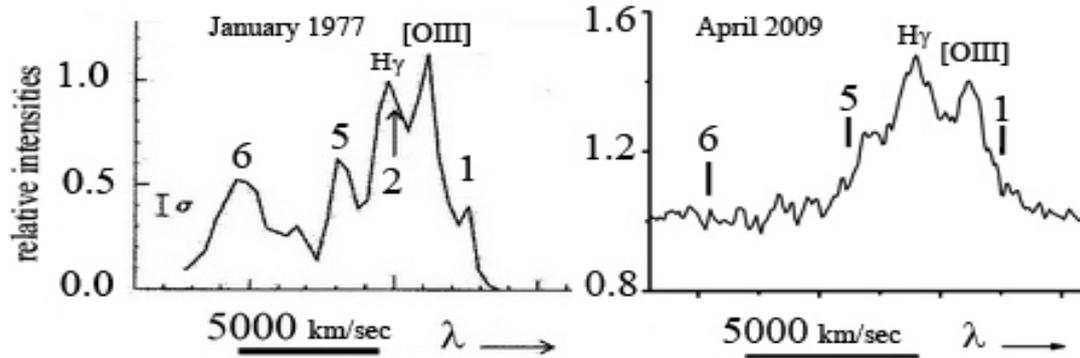


Fig. 1: Multi-component $H\gamma$ line profiles at different evolutionary epochs of the NGC 3227 nucleus

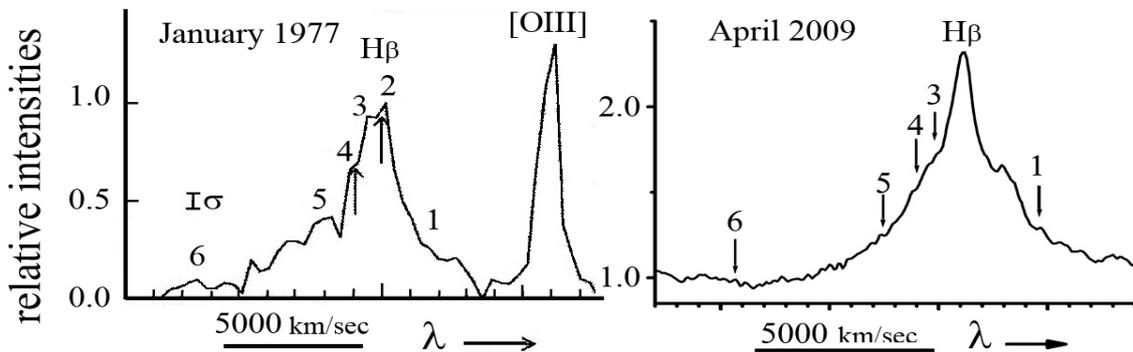


Fig. 2: Multi-component $H\beta$ line profiles at different evolutionary epochs of the NGC 3227 nucleus

The intensities of emission components 1, 5, 6 in 1977 were 35%, 60%, 50% of the peak of $H\gamma$ line brightness, respectively. 30 years later the profile has changed: the intensities of the emission components 1 and 5 were 20%, 30% of the peak brightness of $H\gamma$ line, respectively. Components of the $H\beta$ line profile show the similar variations over the time: the intensities of the emission components 1 and 5 of the $H\beta$ line profile in January 1977 were 25%, 40% of the peak brightness of the $H\beta$ line, respectively. In April 2009 the intensity of these components was only the 5th part of the $H\beta$ line peak brightness.

Conclusions

The comparative analysis of spectral characteristics of the Seyfert galaxy NGC 3227 nucleus and the form of the Balmer line profiles showed their significant variations in the time interval of more than 30 years. These results may point at the fact that 32 years later after the flare in the gas of the Broad line region in January 1977, the

physical conditions in the area of the hydrogen emission lines have changed. During this time there was a weakening of the total activity of the galaxy NGC 3227 nucleus and its gas flow activity as well.

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