ABOUT SOME FEATURES OF SAFERT GALAXIES OF VARIOUS SPECTRAL TYPES AND FLASHES OF TOP SUPERNOVA STARS IN THEM

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Several regularities of variability of the physical parameters dealing with Seyfert galaxies and with the flares of Supernova stars in them are considered in the present article. The review of the works dealing with the variability of the spectral types of the Seyfert galaxies is given in the introduction.

Keywords: Seyfert galaxies – Nuclei of the active galaxies – Black hole – Supernova stars

1. INTRODUCTION

Studies of active galactic nuclei that change the spectral type as a result of significant changes in luminosity are undoubtedly relevant, since they give us very important information for understanding the geometry, physical nature and evolution of active nuclei.

Seyfert galaxies (SG), as a separate class of galaxies, were first identified by the American astronomer Seyfert C. in 1943 [1]. He found in the spectra of 12 galaxies wide lines of hydrogen, helium and ionized iron. The half-width of these lines, in accordance with the Doppler effect, corresponded to speeds of up to several thousand km s^{-1}. Thousands of such objects are now known, and in some of them the emission spectral lines have widths corresponding to speeds of about 30,000 km / s (0.1 the speed of light!). SGs belong to giant spiral galaxies. Among them, the proportion of crossed spirals is especially high (about 70%). Seyfert showed the unusual structure and emission spectra of these galaxies. As is known, SGs are divided into two types according to the width of spectral lines. SGs with wide lines denote Sy1, and with narrow lines, Sy 2. If the ratio of the equiva-

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lent widths of the spectral lines Hβ / [OIII] is 1, then this galaxy belongs to the first spectral type, if this ratio is 0.1, then this is the SG of the second type. In addition, these galaxies are distinguished by the color indices (B-V) and (U-B).

Cases of the transition of an object from one spectral type to another are a definite problem for this model. When, in 1984, changes in the spectral type were discovered in the active core of the galaxy, known as the first type of superlattice (NGC 4151), then only a few such cases were known [2]. Now there are several dozen active galactic nuclei that have changed their spectral type. In a recent study, a group of astronomers focused on one of the clearest examples of such objects - NGC 2617 [3]. In 2013, a team of researchers in the United States discovered [4] that NGC 2617 had changed its spectral type, and the internal areas that were hidden from us were now visible. It is not known how long this object will remain in this new state.

Despite some successes in the unification model, there are still some problems that cannot be explained solely by the dimming associated with different orientations with respect to the observer. In many Type II YAGs, a hidden region of wide emission lines is not observed even with very deep observations in polarized light. In addition, the X-ray spectra of many type II YAGs do not show large column densities of the absorbing gas, as one would expect if these YAGs were surrounded by a radiation absorbing torus. Because of these problems and others [5], other physical models were proposed to explain the differences between the observed types of YAG. In particular, it was suggested that the difference in the types of YAG is associated with different rates of accretion. Trump et. al found a significant difference between the accretion rates of YAGs of type I (L / L Edd$>$ 0.01) and type II (L / LEdd $<$0.01, where L is the internal bolometric luminosity of the nucleus, LEdd is the Eddington luminosity), which implies that the accretion rates, and not only geometric orientation should play a large role in the characteristics of emission lines observed in YAG spectra.

Changes in the spectral type observed in dozens of YAGs in a relatively short time also pose a certain problem for the unification model, since it must be modified in such a way that these fairly frequent changes in the YAG type find a natural explanation in it, or a new model must be created to interpret various types of YAG. For this, first of all, an understanding of the physics of changes in the types of YAG is necessary. YAGs that change their type have been intensively studied in recent years and have received a special name in English - Changing Look AGN (CL AGN). In Russian, there is no universally accepted designation of such objects, so below we will use the English abbreviation. CL AGNs are objects in which dramatic changes in the emission line profiles occurred, in which type changes were observed from one spectral class to another over a very short time interval (from several days to several years). Currently, several dozen CL

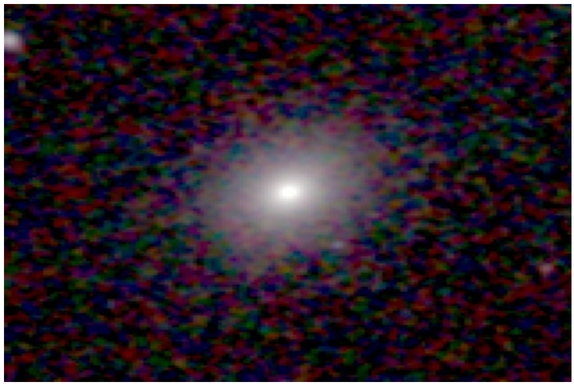

Fig. 1. Seyfert Galaxy NGC 1218, S0 / a, Sy 1

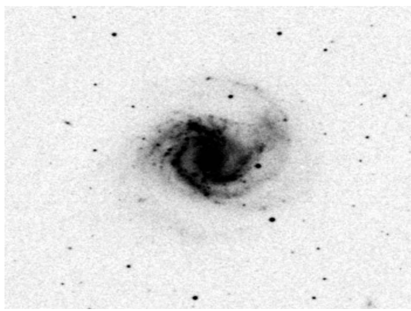

Fig. 2. Seyfert Galaxy NGC 4303, SBa (rs) bc? Sy 1.5

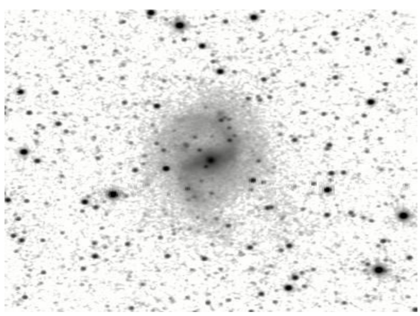

Fig. 3. Seyfert Galaxy NGC 6221, SB (s) c, Sy2

AGNs are known, although this small amount is comparable to the number of intensively studied AGN spectral variability. Accordingly, it can be assumed that each strongly variable AGN can be assigned to CL AGN if it is observed for a sufficiently long time [3]. This assumption is confirmed by recent studies by Runco et al., [6], which showed that about 38% of 102 SGs changed their type, and about 3% of these objects disappeared broad Hβ lines on a timeline of 3–9 years. Also

MacLeod et al. [7] estimated that > 15% of strongly variable quasars have cases of changing spectral type over a period of about 10 years.

2. SOME OBSERVATIONAL FACTS BY HAGA AND THEIR ANALYSIS

As we already noted, the number of SGs is small and makes up only a few percent of the total number of galaxies. In addition, they are often located quite far from us. All this makes any statistical analysis of observational data quite difficult. In the present work, we selected two data sources [8] and [9], which give the most complete values of the spectral types of the considered SG. The results obtained for the absolute and relative values of the amount of SG of various spectral types are summarized in Table1

Table 1. Absolute and relative number of Seyfert galaxies according to data from [8] and [9].

N[1]	S_p	n_{OTH}	N[2]	n_{OTH}
6024	Sy 2	0.267246	4258	0.283055
1597	Sy 1n	0.070849		
11	Sy 1i	0.000488		
44	Sy 1h	0.001952		
189	Sy 1.9	0.008385	88	0.00585
142	Sy 1.8	0.0063	84	0.005584
361	Sy 1.5	0.016015	285	0.018946
100	Sy 1.2	0.004436	274	0.018214
98	Sy 1.0	0.004348		
13975	Sy 1	0.619981	10054	0.6608351

From Table 1 it can be seen that if the numerical values of the quantities do not really coincide, then their general course repeats each other well. And this, in turn, most likely suggests that the spectral type hyperglyms Sy 1 and Sy 2 have been in a stable state for a long time, while the intermediate spectral types hyperglyphics are unstable and exist in these states for a relatively short time. A change in the spectral type in some SGs was probably first mentioned in [2], as well as in a large number of subsequent works by other authors. Hidden active galactic nuclei become visible when clouds of dust covering them burn through powerful radiation from the vicinity of supermassive black holes.

Figures 1-3 show direct images of some SG spectral classes Sy 1, Sy 1.5 and Sy 2 from the catalog [8]. It is clearly seen that with a change in the spectral type from Sy 1 to Sy 2, the morphological type of SG changes from Sa to SB. But is this pattern global? Unfortunately, it is neither possible to prove this nor refute it today. And the spectral classification and determination of the morphological type of the same SG by different authors are very different (see, for example, the review [9]).

Next, we determined the location of supernova explosions in the SG. There was nothing new compared to ordinary galaxies here - supernova explosions in the arms, on the edge of the arms and between the arms are about two times larger than in the center or in the halo of the SG. And, finally, we calculated the number of type I and type II supernova explosions in SGs of various morphological types (we took data from supernova explosions from the catalog [10]). The data are shown in Table 2.

Table 2. The number of flares of various types and the morphological type of the corresponding Seyfert galaxies.

Type Aux. Morph.type	I	II
Sa	4	7
SAB	5	12
SB	6	2

As can be seen from the table, the number of type II supernovae is maximal for SG of morphological types Sa and S0 (lenticular galaxies), and the picture is opposite for type I flares.

An analysis of the number of different types of supernova explosions helps us in understanding, for example, changes in stellar density for SH of various morphological types. Based on the current understanding of the scenarios of various types of supernova explosions, a type I supernova is a binary star (white dwarf + giant, supergiant) [13]. The existence of such an unusual pair is possible only in the case of capture of one star by another with their sufficient convergence. On the other hand (as will be seen in Fig. 5), SGs of different morphological types have approximately the same mass, but in SB type SGs, all stars are concentrated in two arms and a jumper, while in SG type Sa stars are fairly uniformly distributed throughout disk [14]. Hence, it can be assumed that the stellar density in the arms and jumper of the SB type is higher, and, therefore, the probability of approaching and capture of stars by each other is higher.

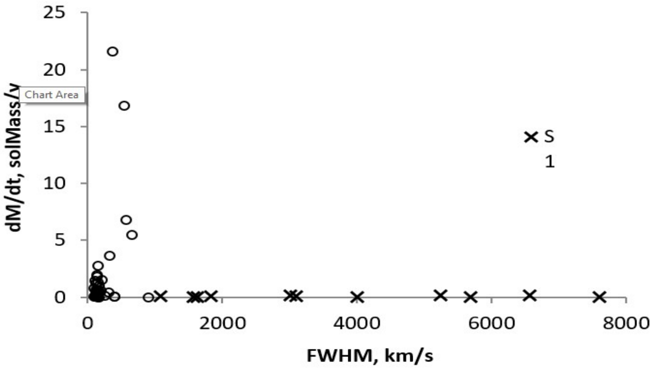

Fig. 4. The relationship between the rotation speed of Seyfert galaxies and the rate of accretion.

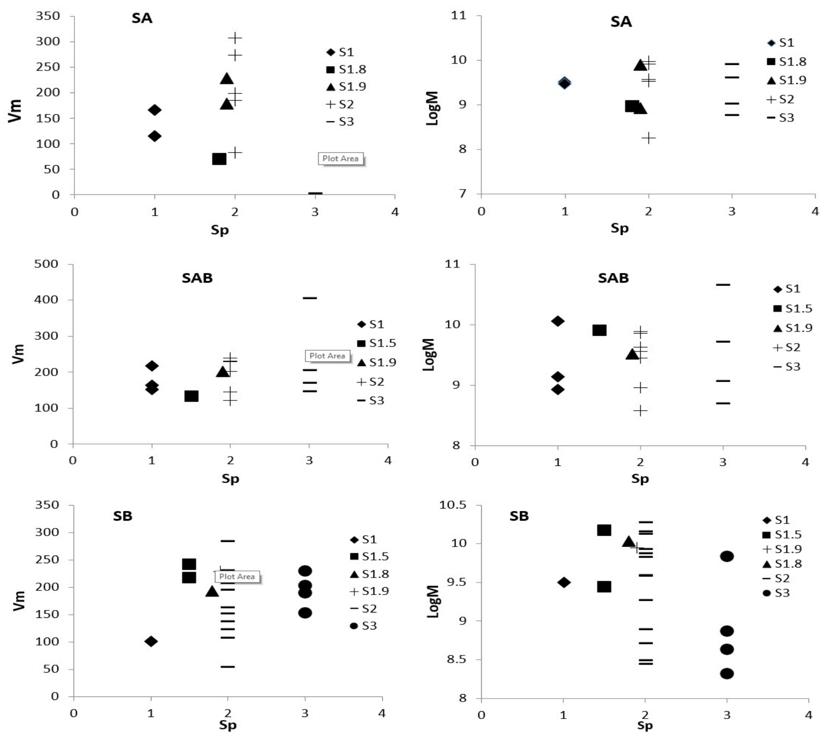

Fig. 5. The maximum SG rotation speed is Vm and log M depending on the spectral class of the SG (abscissa axis, see the legends of the figures).

If, on the basis of overlapping data for the SG from [10], we compare the average masses of the galactic nuclei of the galaxies Sy 1 and Sy 2, then they turned out to be 7.45 and 7.49069 logarithms of solar masses, respectively, i.e. almost equal to each other. If we compare the average values of the accretion rates from the same work for the same galaxies, then it turns out that the accretion rates for the SG of the spectral type Sy 2 are 2.285862, and for Sy 1 - 0.130455 solar masses per year, i.e. here the difference is significant. True, there are about six SGs in the averaging group, whose accretion rates are significantly higher (galaxies with a UV excess), but we still left them averaged to remove a certain risk of subjectivity. Equal average masses of nuclei and significant differences in the rate of accretion allow us to assume that other forces, for example, magnetic, take part in the rate of matter accretion onto the SG core as well as gravity. This is also indicated by Figure 4 (data taken from [13]).

As can be seen from Fig. 4, the SH of the first type (Sy1) has approximately the same and very small rates of accretion. While SH of the second type (Sy 2) in a relatively small interval of rotation velocities ($\sim$ 1000 km / s) can have the most varied values of accretion rates, the reason for this could be the presence of a magnetic field of a nucleus (or perinuclear accretion disk) in these SH) [13].

Here it should be noted such an effect: If we plot the dependence of the SG radial velocity on the angle of inclination of the plane of these galaxies to the line of sight, then the graph will show some correlation of these parameters. Near the value of 90°, radial velocities are maximum, and towards 0° and 180° these values decrease (data from the site of the Center for Astronomical Data in Strasbourg [12]). In our opinion, this effect is associated with observational selection - the closer the galaxy is to the "off" position, the more difficult it is to detect it, and the more measure its parameters.

As can be seen from Figure 5, on average, the logM values for SGs of different morphological types and spectral classes are the same, while the values of the maximum rotation speed show a more complex dependence (data taken from [[15]]).

3. RESULTS

1. SGs of the spectral type Sy 1 and Sy 2 are in a stable, stable state for a long time, while SGs of the intermediate spectral types are unstable and exist in these states for a relatively short time and change their spectral type from time to time.

2. The number of type II supernovae is maximum for SH of the morphological types Sa and S0, and the opposite is true for type I flares.

3. Equal average masses of nuclei and significant differences in the rate of accretion allow us to assume that other forces, for example, magnetic, take part in the rate of matter accretion onto the core, in addition to gravity.

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