SPECTRAL CLASSIFICATION OF THE SEYFERT GALAXIES.

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On the base of large inclination to the plane of the rotation of the Seyfert galaxies was made for the θ variations spectral in the article. The course of coefficients and redness lines with a change in the spectral class of Seyfert galaxies was analyzed.

Keywords: Seyfert galaxies–spectral types of Seyfert galaxies.

1. INTRODUCTION

Since the time of discovery of the first quasars in the 60s of the XX century, astronomers had tried to restore some order on dozens of objects known as active galactic nuclei (AGN), which also include Seyfert galaxies. These are supermassive black holes at the centers of galaxies, intensively accreting matter (unlike relatively "silent" black holes such as Sagit tarius A at the center of our galaxy). This problem is a complex task. The breakthrough took place in the 1980s when some of the peculiarities of AGN researchers were tried to explain by the differences in the orientation of the galactic plane (and consequently by the circumnuclear torus's orientation to the line of sight, for example [1]). A similar model was named the unification model of AGN. In the unification model, two main zones of AGN are postulated, emitting broad emission lines (type I) and only narrow lines (type II), which are the same types of objects, but, at the same time, AGN of type 1 have broad emission lines and more high level of continuum emission. In contrast, type II AGN, has no broad lines and has only very narrow emission lines and a weaker continum. The idea of the unification model lies in the fact that the central black hole is surrounded by darker torus consisting of gas and dust, at the same time, the torus is visible to the observer (like the galactic disc) either as a flame ($\theta \sim 90°$) or from the edge ($\theta \sim 0°$, $180°$). It is clear that

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intermediate values of θ are possible here (where θ - the angle between the plane of rotation of the galaxy and the line of sight). Consequently, if broad emission lines are formed in the region close to the central black hole, and narrow forbidden lines are emitted at a more remote distance outside the torus (in a region with a low density of interstellar matter), then the broad lines might be hidden depending on the angle, under which AGN are visible. The best evidence of this scenario is the spectropolarimetric observations of some AGN types II in which, in polarized light, broad emission lines are visible, which can happen if the region of emission of the broad line is hidden. Despite some successes of this unification scheme, some problems cannot be explained solely by eclipses, by clouds of interstellar gas-dust matter related with various torus orientations regarding the observer. Many AGN of type II does not have a hidden region of broad emission lines, even with profound observations in polarized light. Besides, X-ray spectra of many AGN type II do not indicate high column densities of the absorbing gas, as would be expected if these AGN were surrounded by absorbing torus. Because of these and other problems, for example, in work [2], another physical model to explain the differences between the observed types of AGN was proposed. Particularly, it was proposed that the difference in types of AGN is related to different accretion rates of interstellar matter onto the core. The authors found significant variance between the accretion rates of AGN of type I (L/L Edd$>$ 0.01) and AGN of type II (L / L Edd $<$0.01), where L - the internal bolometric luminosity of the core, L Edd - the Eddington luminosity, which implies that the accretion rate, and not only geometric orientation, should play a significant role in the characteristics of emission lines observed in spectra of AGN.

Recently, increasingly observational works have appeared, in which cases of changes in the spectral type of dozens AGN in a relatively short time are described, i.e., dramatic changes occur in the profiles of emission lines of classification type of some AGN, in which changes from one spectral type to another are observed within a short time interval (from days to several years). It presents a particular problem for the unification model since it should be modified so that these relatively frequent changes in the spectral type of AGN would find a natural explanation in it, or a new model should be created to interpret various types of AGN. Firstly, for this, it is necessary to understand the physics of changing the types of AGN.

Currently, Seyfert galaxies researchers put forward various assumptions related to the nuclei of Seyfert galaxies. For example, in work [3], the authors consider that the spectral type changes are characteristic for all Seyfert galaxies. It merely needs to observe these galaxies for a long time. Besides, in the unification model, the cases require an explanation when broad emission lines disappear or weaken for a relatively short time (months - several years, works [4–7]).

Data analysis. Let us find out as far as the observed data on Seyfert galaxies corresponds to the models mentioned above and whether they are the goal of this work. If we analyze the behavior of the dependence of the photometric index (ug) on the spectral type (see Fig. 1), then the obtained picture fits well into our ideas about the evolution of galaxies (we took the data from the review [8] for several observation sites most affluent in Seyfert galaxies, in the ugriz photometric system, with consideration of redness). It can be seen from the figure with the variation of spectral type from Sy1 to Sy2, the value of (u-g) increases, possibly related to the relative decrease of the number of stars of early spectral types with the evolution of galaxies. Unfortunately, direct proof of this assumption in our case is impossible (see Fig. 2) since the data on the ages of the corresponding galaxies taken by us from [8] are calculated (age at redshift), i.e., based on some assumptions. Based on the small number of points in Fig. 2 and their significant

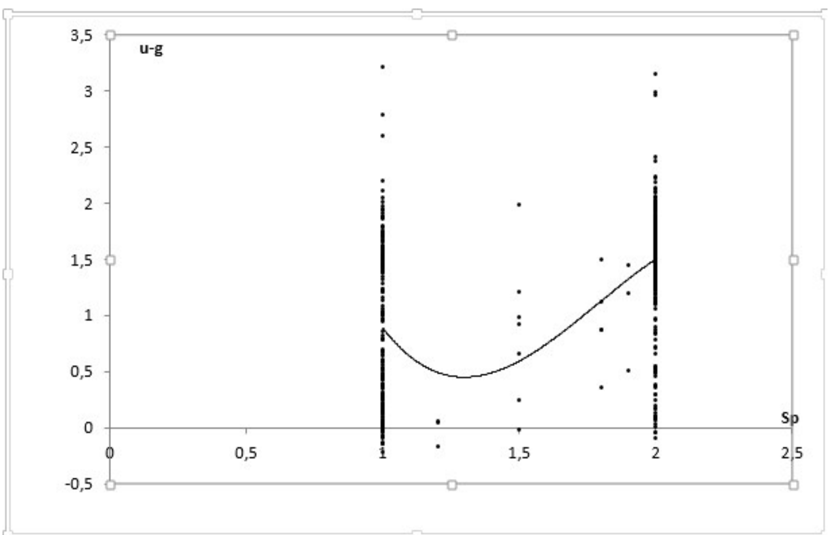

Fig. 1. Dependence of the color-index (u-g) values on the spectral type for Seyfert galaxies from overview [8] for some observation sites. Number of galaxies – 559. The fine line on the figure - the third-degree polynomial trend.

scattering, it is difficult to draw any conclusions about the variation of dependence. Consequently, at this stage, it is early to draw any conclusions about the evolutionary course of Seyfert galaxies of various spectral types, although the fact that some of them change their spectral type from time to time gives us some hope. However, it is first necessary to ensure that the inclination to the plane of rotation of Seyfert galaxies affects their spectral type in accordance with the unification model.

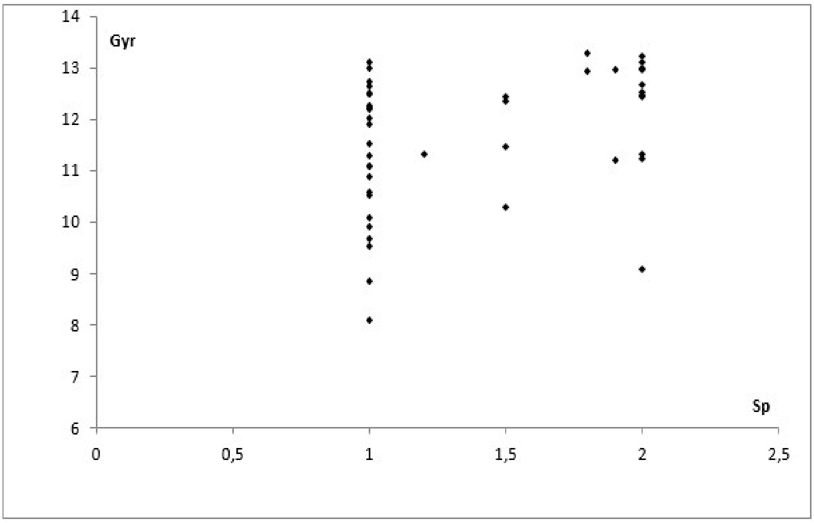

Fig. 2. Dependence of the age of the Seyfert galaxies from [8] on the spectral type. The number of galaxies - 45.

For this purpose, based on data from the catalog [9], we built up histograms (see Fig. 3-6) of the distribution of the number of Seyfert galaxies, depending on the inclination of their rotation plane to the line of sight (θ°) for galaxies of spectral types Sy1, Sy2, Sy1.5, and Sy1.9, respectively. The data on the values of angle of inclination was taken from the site [9].

The data in [9] for Seyfert galaxies of spectral types Sy1.2 and Sy1.8 are too few for statistical analysis. As can be seen from Fig.3-6, if the corresponding distributions for Seyfert galaxies of types Sy1 and Sy2 are close to standard (continuous curves in the figures), the picture is different for types Sy1.5 and Sy1.9 Here the distribution maxima shift to the values $\theta \sim \theta^{\circ}$, 180°, i.e., in this case, we observe the galaxy from the edge. The relatively small number of Seyfert galaxies of spectral types Sy1.2, Sy1.5, Sy1.8, and Sy1.9 can be explained by the flocculent structure of interstellar matter, hence the short duration of eclipses and the presence of Seyfert galaxies in an eclipse state in general, and accordingly changes of their spectral class. Incidentally, the second model with a change of the accretion rate does not contradict this.

Consider a two-index diagram (U-B) on (B-V) for Seyfert galaxies, constructed separately for various spectral types. Usually, it is constructed for stars to determine interstellar redness. The points on it, corresponding to stars with different redness of the same spectral type, fall on one straight line (redness line). We constructed a similar diagram for Seyfert galaxies; then, we draw inclined lines through the point arrays separately for each spectral type using the least-squares

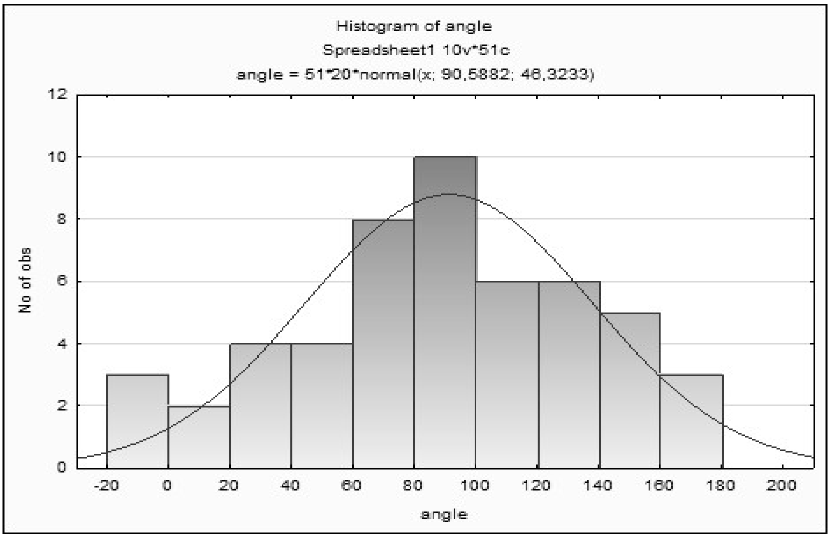

Fig. 3. Distribution of the number (ordinate axis) of Seyfert galaxies of type Sy1 depending on the angle of inclination of their plane of rotation to the line of sight (abscissa axis, in degrees). The number of data for galaxies of type Sy1 - 13975.

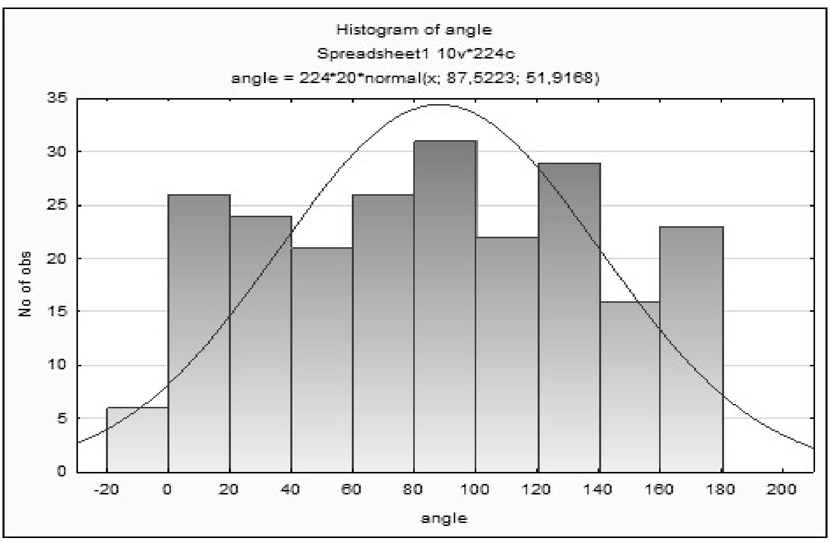

Fig. 4. Distribution of the number (ordinate axis) of Seyfert galaxies of type Sy1.5, depending on the angle of inclination of their plane of rotation to the line of sight (abscissa axis, in degrees). The number of data for galaxies of type Sy1.5 -361.

method. Then we have constructed a plot of the magnitude of the inclination coefficient α from the spectral type (Fig.7). As shown in Fig. 7, the value A increases by the jump from type Sy1 to type Sy1 2 and then monotonically de-

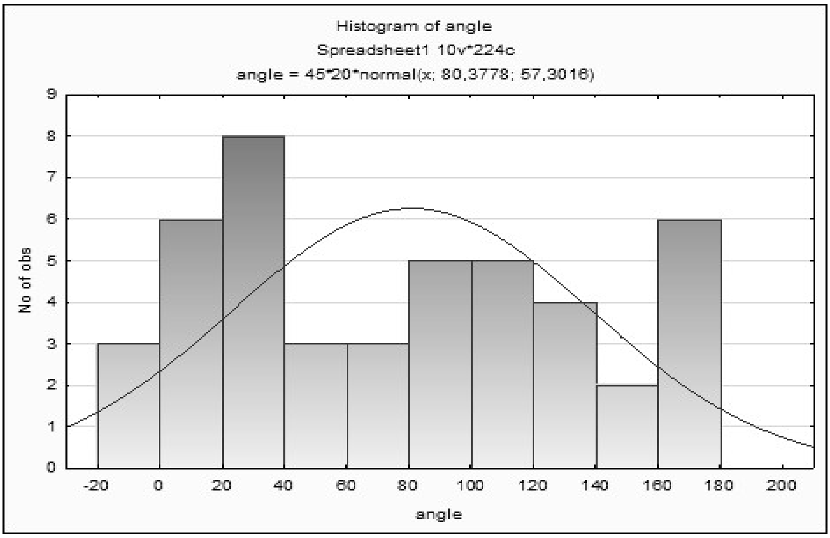

Fig. 5. Distribution of the number (ordinate axis) of Seyfert galaxies of type Sy1.9, depending on the angle of inclination of their plane of rotation to the line of sight (abscissa axis, in degrees). The number of data for galaxies of type Sy1.9 – 189.

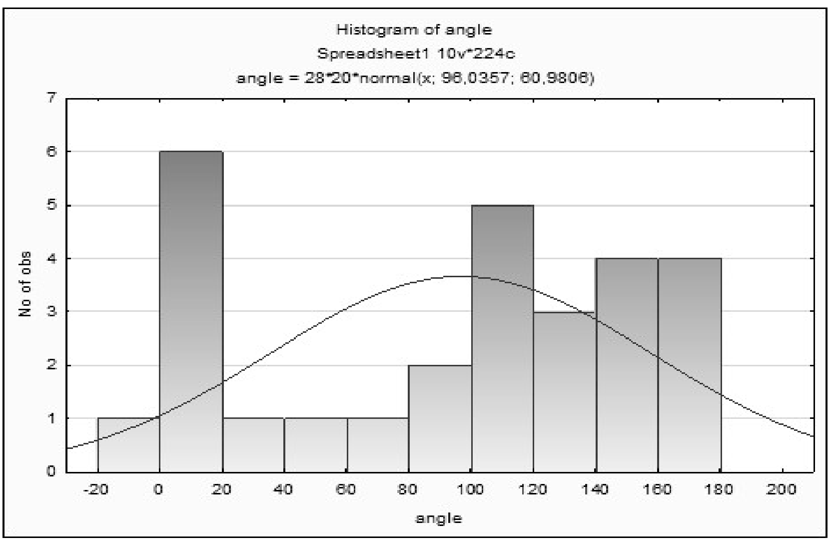

Fig. 6. Distribution of the number (ordinate axis) of Seyfert galaxies of type Sy2, depending on the angle of inclination of their plane of rotation to the line of sight (abscissa axis, in degrees). The number of data for galaxies of type Sy2 - 6024.

creases to type Sy2. It is probably due to gas-dust matter density in the disk of corresponding galaxies (see Fig. 1 of the present paper).

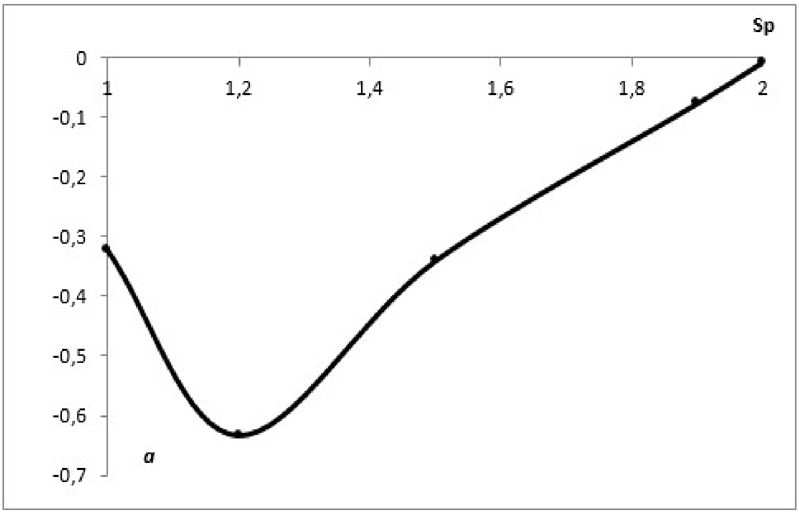

Fig. 7. Change of the inclination of the redness line from the spectral type of Seyfert galaxies.

2. CONCLUSION.

Thus, the following conclusions can be drawn from this work:

1. Observed data confirm the correlation between the angle of inclination of the plane of rotation of Seyfert galaxies and the line of sight and spectral type. It is probably due to eclipses of emission from the core, clouds of gas-dust interstellar matter of the disk, and the matter of the circumnuclear torus.

2. The density of gas - dust matter varies depending on the spectral type of Seyfert galaxies.

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