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ON SPECTRAL CLASSES OF SEYFERT GALAXIES AND THEIR EVOLUTION

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The paper analyzes changes in some physical parameters obtained from theoretical, model calculations in several catalogs for Seyfert galaxies of spectral classes S1 and S2. It is concluded that there is a high probability that the existing evolution of Seyfert galaxies occurs from the spectral class S2 to S1. Based on the analysis of a large array of observational material, it is shown. that the distribution of Seyfert galaxies as a spectral class Sy1. so Sy2 has a bimodal character.

Keywords: Seyfert galaxies –spectral types of Seyfert galaxies – Evolution Seyfert galaxies

1. INTRODUCTION

Since the discovery of the first quasars in the 60s of the XX century, astronomers have tried to bring at least some order to a variety of objects known as galaxies with active nuclei (AGN) which include Seyfert galaxies (hereinafter referred to as SG). These galaxies have supermassive black holes in the center, intensively accreting the extragalactic matter of these galaxies. Further on the basil of ordinary classical mechanics we will try to explain the existing difference between the SGs of different spectral classes.

2. EVOLUTION OF SG AND THEIR DISTRIBUTION IN THE UNIVERSE

At first let us consider a graph of the dependence of the logarithm of the accretion rates of extragalactic matter (log(dM/dt)) on the nucleus on the rotation

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rate of the SG (in our case, this is the FWHM index). These values are obtained directly from observations and the method of their calculation is generally recognized by astronomers. Data for the graphs are taken from the work [4]. (Star

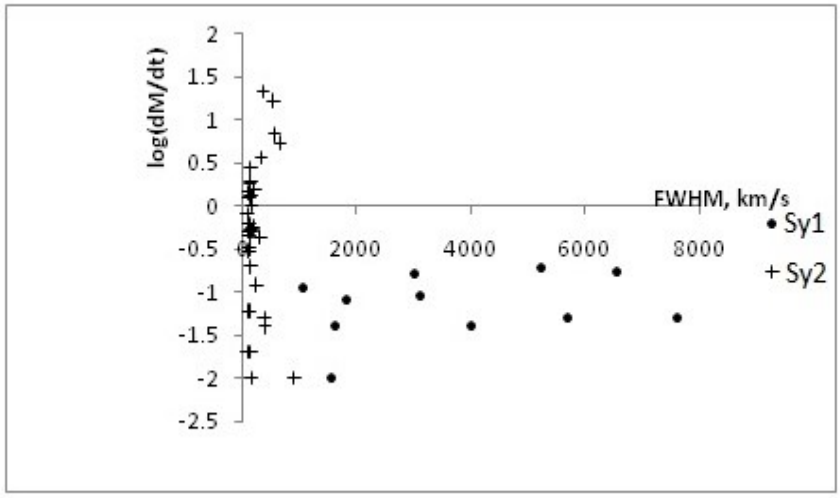

Fig. 1. The dependence of the logarithm of the accretion rates of extragalactic matter on the nucleus on the rotational velocity of the disk of the SG spectral classes Sy 1 and Sy2. Here the points are SG spectral class Sy 1, and the crosses are Sy 2.

formation rate in Seyfert galaxies (Wang+, 2007)).

This figure can be interpreted within the framework of classical mechanics. The fact is that the rotation speed of the SG spectral class Sy1 (as can be seen from the figure) is higher than that of the Sy2 and the resulting centrifugal force prevents accretion. It is also worth mentioning here that if we accept the hypothesis of the presence of evolution in SG in which one spectral class passes into another then at the grossest approximation (if we assume that in SH spectral class Sy1 the morphological type is mainly SA, and in spectral class Sy2 it is SB), then in the first case it is possible to represent SG as a homogeneous disk, rotating around an axis perpendicular to the disk and passing through its center, and in the second case, as a homogeneous rod rotating around a perpendicular axis, then in the first case the moment of inertia of the disk is less than that of a rotating rod and, based on the law of conservation of angular momentum, the disk must rotate faster than the rod (since the mass of the SG of these spectral

classes is on average approximately the same). Such a hypothesis requires the presence of some catastrophic mechanism, not yet very clear, for the transformation of one morphological type into another. From Figure 2 it can be seen that

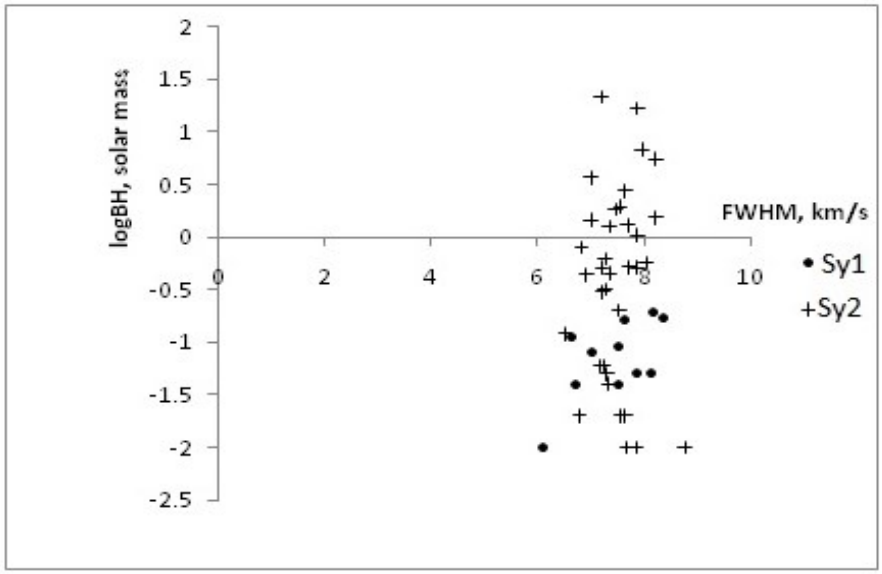

Fig. 2. The dependence of the mass of the SG nucleus of different spectral classes for the different rotational speeds (here the same designations as in Fig.1).

if in the lower part of the figure the mass of the central black hole of the SG of different spectral classes are mixed, then only the SG of the second spectral class remain in the upper part of the figure, i.e. in this case, accretion constantly goes to the core of the SG, which leads to an increase in the mass of the nuclei of these galaxies, as can be seen from the figure. Let us now turn to the analysis of such important parameters for the evolution of galaxies as the rate of star formation (SFR). Previously, it was believed that because during the transition from SG spectral class Sy1 to Sy2, on average, the color indices become redder, then this indicates the evolutionary path of SG, the rate of star formation falls, more and more low-mass, cold stars are born, i.e. such SG is aging. But then there were works in which (see, for example, [1]) this statement is questioned. On the contrary the authors of these works believe that in SG spectral class Sy2, the rate of star formation increases, and the infrared excess in colors arises mainly due to the fact that a large amount of dust in these galaxies is heated by the radiation of massive, hot stars. The fact that there is more dust in the SG spectral class Sy2

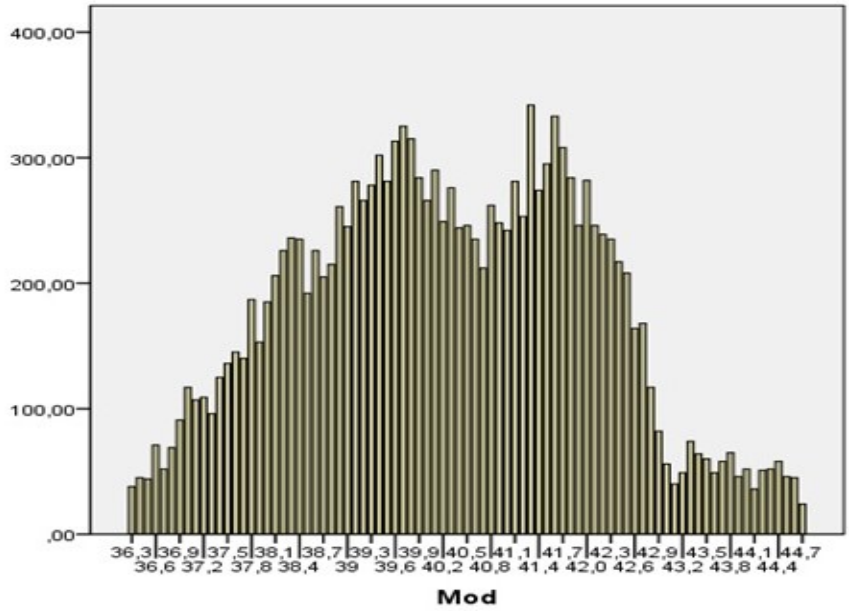

Fig. 3. Distribution of the number of SG spectral class Sy1 depending on the magnitude of the modulus of their distances.

than in Sy1 is also evidenced by our own research. Let's try to solve the resulting contradiction by analyzing the frequency of supernova flares in SG, because if the rate of star formation is large, then more massive, hot stars are born and their explosions also often occur. For this reason we selected from the catalog [5] SG, in which supernova explosions have ever occurred. SG spectral class, Sy1 had seven supernova flares (of which three are repeated flares in the same galaxy) and SG spectral class Sy2 already had thirty-seven (of which eight are repeated), and if considering that for example, [6] (ned.ipac.caltech.edu). gives data for Sy1 spectral class Sy1 about twice as much as for Sy2, as well as then, that the SG in the Universe is only 1-3% of the total number of galaxies, it becomes clear that supernova explosions in the Sy2 spectral class Sy2 are possibly even greater than in ordinary galaxies and there is no need to talk about a decrease in the rate of star formation. But if the rate of star formation in the Sy2 spectral class Sy2 is large, based on the frequency of supernova explosions, then it becomes clear where so much dust comes from in these galaxies. And finally, we can refer here to the fundamental principle of our Universe that entropy grows over time, which no one has yet cancelled.

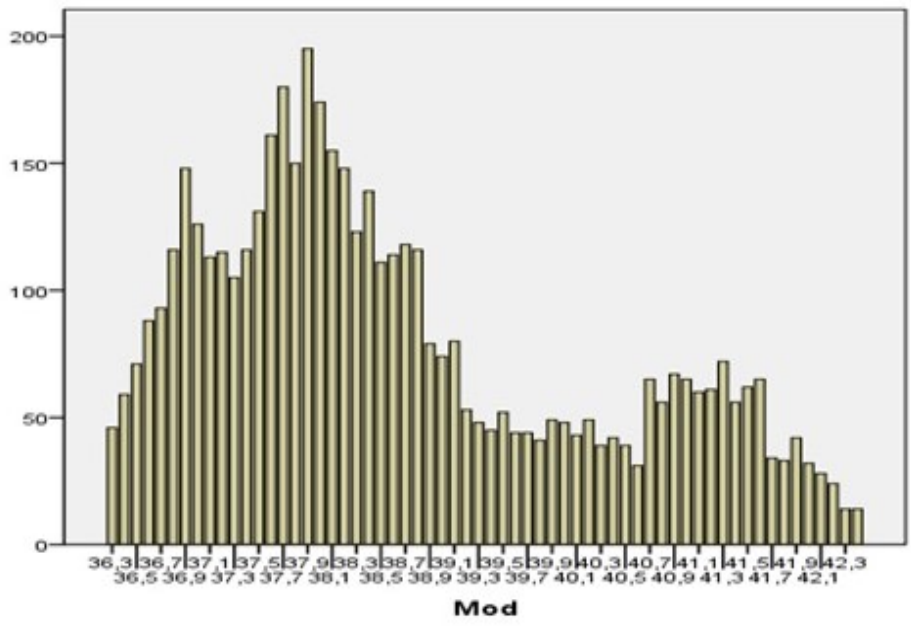

Fig. 4. Distribution of the number of SG spectral class Sy2 depending on the magnitude of the modulus of their distances.

Whether Seyfert galaxies evolve, what are the mechanisms of this evolution, the ways of evolution are today perhaps the most important questions in the light of understanding the nature of these objects, their formation. SGs are known to be divided into spectral classes. In this work paper, we attempt to determine the path of evolution of SG of various spectral classes. Similar work has already been performed (see, for example, [2]), but in our work on the bases of much more observational material and by another method it is shown that the evolution of SG of different spectral classes goes in the direction of Sy2→Sy1.

Since determining the distance to extragalactic objects is associated with certain difficulties, we use a well-known, so-called distance module Mod, in this work, where

$$\text{Mod} = m_v - M_v = 5\log_{10} r - 5 + A(r)$$

Here, m_v and M_v are the visual and absolute magnitude of the extragalactic object in filter V, respectively, r is the distance, A(r) is the interstellar absorption.

Given that the interstellar absorption in our case is relatively small ($A(r) \approx 0^m.1$ compared to the $Mod \approx 39^m$ value), we neglect this value in our further calculations. Further, we constructed the distribution curves of the number of SG spectral classes Sy1 and Sy2 separately, which are presented in Fig.

3 and Fig. 4. Here I had to round the values of mv to $0^m.1$, because with such accuracy in the work [3] the values of Mv are given. As can be seen from the figures, the resulting distribution curves are bimodal in nature. Most likely this is due to the fact that the distribution of MV values in [3] also has a bimodal

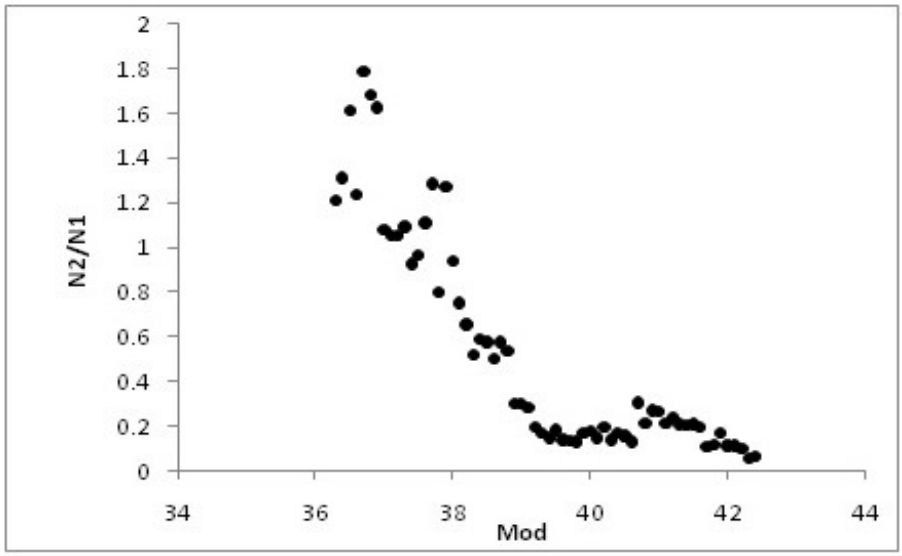

Fig. 5. Distribution of the number of SG spectral class Sy2 depending on the magnitude of the modulus of their distances.

character and froceed from it we will preliminarily introduce names for the left modes in Fig. 3 and 4 SG, low luminosity and for right modes high luminosity.

As can be seen from the above figures 3 and 4 if for the spectral class Sy1 both modes have approximately the same amplitude on the bimodal distribution curve then for the Sy2 spectral class, the right mode in the figure is about two times smaller in the amplitude of the left while the location of both modes in the figures is approximately the same (relative to the values of the modulus of distances) and the border between the modes passes approximately in the same place in both figures. Letus consider now how the number of SGs in the universe surrounding the Earth changes, depending on the modulus of distance. For this reason we will break the space surrounding the Earth into globular layers, with a thickness of $\Delta Mod = 0^m.1$ centered at the location of the Earth, and calculates the number of spectral classes SG Sy1 and Sy2 in each ball layer separately. Then we build

the dependence of the values N(Sy2)/N(Sy1) (since the volume of the ball layers under consideration is different) depending on the distance modulus (Fig. 5).

3. CONCLUSION

Thus the present work confirms the conclusion made in the work [1] that the evolution of SH goes in the direction from the spectral class Sy2 to the spectral class Sy1, made on the basis of the analysis of a more extensive observational material and by another method.

The distribution of the number of SG of the spectral class Sy1 and Sy2, depending on the magnitude of the modulus of their distances, has a bimodal character.

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