

EVOLUTIONARY SCHEMES FOR OBJECTS WITH ACTIVE NUCLEI

B. V. Komberg

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16. Abstract The analysis of observational properties of quasistellar objects (QSO) reveals that they are extremely violent nuclei of distant galaxies. But it remains still an open question at what stage of evolution (initial, intermediate-recurrent, final) these galaxies are? Various published attempts to classify QSO under different criteria - including the one based on the morphological type of the surrounding galaxy E or S; - are analysed. There are evidences that radioactive quasars (OSS) reside in E -, while radio-quiet (QSG) in both E- and S- systems. The latter (QSG-S) may be evolutionary connected to Seyfert-like objects (Sy). A correlation between the nuclei activity level in systems of different morphological type and the relative amount of gas in them is noted. A conclusion is made that from the point of view of activity level and the duration of active stage of nuclei an interaction of galaxies with the intergalactic medium is of particular importance. And the most conspicuous this must be in spheroidal systems of central regions of rich clusters, in tight groups and binary galaxies.			
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EVOLUTIONARY SCHEMES FOR OBJECTS WITH ACTIVE NUCLEI

B. V. Komberg

1. Analysis of the observational properties of quasi-stellar objects (QSO) shows that they are very active nuclei in remote galaxies. However, the question as to the stage of cosmological evolution (initial, intermediate-recurrent, final) of these galaxies remains open.

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2. Attempts presented in the literature to divide QSO into different groups according to different criteria, including division according to morphological type (E or S) of the surrounding galaxy, are considered. There is evidence indicating that radioactive quasars (QSS) are located in E systems, while radio-quiet quasars (QSG) are located in both E and S systems. The latter QSG(S) may be related evolutionarily to Seyfert-like objects (Sy).

3. The basic properties of Sy galaxies in different observational ranges are discussed and it is noted that the division of the spectra into types Sy 0-I, Sy I-II and Sy II can be traced in all objects with active nuclei.

4. An evolutionary scheme for quasar-like objects in E and S systems is proposed, according to which QSS, QSG(E) and QSG(S) are the turbulent initial phases of activity of nuclei, while radio galaxies (RG), emission E galaxies and Sy II are correspondingly later and less active stages. The existence of non-radioactive N galaxies with properties intermediate between QSG(E) and emission E galaxies is predicted, as well as an evolutionary relation between objects with Sy 0, Sy I, Sy II spectral types.

5. A relation is noted between the degree of activity of nuclei in systems of various morphological types and their relative gas content. The conclusion is reached that the interaction of galaxies with the intergalactic medium is important from the point of view of the degree of activity and the duration of the active stage of nuclei. This must be particularly striking for spheroidal

* Numbers in margin indicate pagination of original foreign text.

systems in the central regions of rich clusters, in close groups and pairs of galaxies.

I. It has now been determined that quasi-stellar objects (QSO) are /5
 very active nuclei in remote galaxies. This is confirmed by a number of indirect facts, for example, the continuity of certain parameters (luminosity in the radio, optical,^{*)} x-ray, infrared regions, in the Balmer lines, radio dimensions) between QSO and other quasar-like objects. One can also refer to the incidence of the brightest QSO on the shifted extension of the Hubble dependence $m(F)$ constructed from the brightest galaxies of clusters. A number of direct observational arguments have also appeared in recent years: the observation of individual weak galaxies (or groups of galaxies) with close Z near a number of close QSO and the discovery around close faint QSO of nebulae of galactic dimensions with low surface brightness, which are similar in color and luminosity to galaxies (for a discussion of these problems, cf. for example, [1a, 2]). However, questions of the morphological types of galaxies related to QSO, their place among the other metagalactic populations and the phase of their cosmological evolution (initial, intermediate-recurrent or final) remain open as yet. For this reason, different authors maintain different points of view (for surveys of these problems, cf., for example, [3, 4]). Some assume that QSO are active nuclei in young galaxies [5, 6], others -- in old galaxies [7], and yet others -- in protogalaxies [8, 9]. Each of these points of view has its difficulties. For example, if a QSO is the nucleus of a young galaxy, it is then necessary to explain for near QSO why its stellar formation has been delayed for billions of years; if the QSO is the nucleus of old system, then it is necessary /6
 to understand how the activity of the nucleus can be maintained for billions of years. To be sure, there may very well coexist among QSO objects of a different kind at different phases of their evolution besides. This is especially likely since catalogues of QSO contain objects over a wide range of Z and luminosities both in the optical and radio ranges.

Attempts have long since been made to divide QSO according to some criterion into subgroups. They are divided according to radio power into radio-active QSS ($P_r \geq 10^{43}$ erg/sec). It has been found that there are 50 times more QSG per unit volume. This is reminiscent of the ratio between the number of

^{*)} For example, according to [1], the luminosities at $\lambda = 3000 \text{ \AA}$ of the brightest normal galaxies $\sim 7 \cdot 10^{28}$ erg/sec-Hz, $Sy II - 10^{29}$, $Sy I - 10^{30}$ and QSO - 10^{32} erg/sec-Hz.

normal bright E galaxies and radio galaxies (RG). It has also been found that the radio luminosity functions of QSG and the nuclei of normal E galaxies ($P_r > 10^{39}$ erg/sec) merge [10]. It is interesting that the probability of an object being a radio source (RS) increases with an increase in its total optical luminosity (i.e., mass) approximately as $P_r^{tot} \sim (P_{opt}^{tot})^2$. However, if only the radio emission from compact radio sources related to nuclei is taken, then $P_r^a \sim (P_{opt}^{tot})^3$. If only nonthermal optical radiation is taken into account, then most likely

$P_r^a \sim P_{opt}^a$ [11, 12]. The separation of QSS into objects with steep radio spectra ($\alpha \geq 0.5$) and flat ($\alpha \leq 0.5$) has led to interesting conclusions. It was found [13] that the spacial density of QSS with flat spectra increases with increasing Z not as steeply as for QSS with steep spectra.^{*)} To be sure, it is not yet possible to exclude that a selection is involved here, related to evidence of a difference in radio properties of extended radio components ($\alpha > 0.5$) and compact ($\alpha < 0.5$). In fact, the lifetime of these components differ. While extended components can "live" billions of years, compact components are already strongly attenuated after 10^6 years, and such an object cannot reach the class QSS. Attempts to divide QSO into local and cosmological (cf., for example, [14]) also still continue. Some observational data have also appeared recently about the properties of QSO in the sense of the morphological type of galaxies, the nuclei of which they are. We will discuss this important question in more detail. /7

II. QSS as strong radio sources, by analogy with RG, are usually related to E galaxies. However, it is found that nuclei in plane S-galaxies are also encountered among quasar-like objects. Indirect arguments on that note were expressed previously [15]. They were related to evidence of the avoidance of QSO of regions occupied by rich clusters in contradiction of data on radio galaxies [16]. This contradiction is also maintained for close ($Z \leq 0.2$) QSO which avoid rich Abell clusters with $Z \leq 0.2$. From this point of view, QSO are most similar to S galaxies, which are also rare in the central regions of clusters. According to a selection of 100 galaxies [15], we have

^{*)} Cf. also [13a] where it was shown that for QSS with $\alpha < 0.5$, there are dependencies between the optical luminosity and the width of the line with IV 1550 Å in the spectra of these QSS.

	Type of Galaxy (%)		
	cD	E+S0	S+Ir
Galaxies in rich clusters	93	56	98
Galaxies in poor clusters	6	20	14
Field clusters	1	24	48

Conclusions about the identification of QSS with galaxies of one type or another can also be made from the form of their radio structure. If QSS have widely spaced ($\ell > 50$ kpc) radio components, they are certainly related to E galaxies. This confidence is based on the fact that, on one hand, not one of the S galaxies studied in the radio range has an extended radio structure outside its optical image, i.e., $\ell \leq 30$ kpc. However, if a QSS is identified with a compact RS, then it is not possible to reach a unique conclusion about the morphology of the galaxy related to it; compact RS occur both in the nucleus of E as well as S galaxies.

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There have now appeared direct observations of galaxies around QSO nuclei of N galaxies and objects of the type B Lacertae. Multicolor electrophotometry and electronography carried out with diaphragms of differing angular sizes permit obtaining the distribution of surface brightness and color over the radius of the object. This also makes it possible, in principle, to determine its morphography. To be sure, as was shown in [17], this is possible in practice only for relatively close ($z < 0.3$) and optically faint ($m > 17$) sources, when the bright nucleus is not blurred on the photograph by a surrounding galaxy with a low surface brightness. About three-tenths of the objects (Table 1) have already been studied by this method. The presence of E galaxies has been concluded for a majority of them (for example, [18, 19]). However, the possibility of S galaxies is assumed in some cases (Table 1).

The vicinity of the quasar 3C 48 has been studied in the most detail. A reddish nebula, ellipsoidal in form ($6'' \times 12'' = [15 \text{ kpc} \times 30 \text{ kpc}]$) with an average surface brightness $23.7^m/a'$ was observed around this quasar in 1963 [20]. The brightest region of the nebula extends $5;25$ to the north and $4''$ to the south of the quasar itself. In general, 3C 48 is not a standard QSO; it has a relatively low absolute stellar magnitude (-24), weak radio luminosity ($P_{10} = 3 \times 10^{42} \text{ erg/sec}$) and

compact ($< 1''$) radio structure. Moreover, 3C 48 is not variable in the radio range and weakly variable in the optical ($\Delta m \approx 0.4$). All this permitted referring it to the type of N-galaxies in work [3]. Spectra of the nebula at 4" (approximately 10 kpc) to the north and south of 3C 48 were obtained in work [21]. Sharp emission lines [O III] 5007 and 4959 Å were seen in the northern spectrum with equivalent widths greater than in the spectrum of the quasar itself (due to strong absorption of the continuum in the nebula). Moreover, these lines are red-shifted with respect to the lines of the quasar by $\Delta z = 0.0019$, which corresponds to velocities of approximately 420 km/sec. in the 3C 48 system. No stellar absorption lines are observed in the nebula, while the allowed Balmer lines, if there are any, are much weaker than in the spectrum of the QSO itself. /9

Spectroscopic analysis of the spectrum of the nebula around 3C 48 was carried in [22], where its similarities to the spectra of giant HII regions is indicated. To interpret the observations, a model is proposed in which the gas of the disk of a giant S-galaxy with average density $4 \cdot 10^{-2}$ and normal chemical composition is ionized by soft X-rays (0.4 - 0.1 keV) from a central non-thermal source. It is interesting that on good photographs of 3C 48, there are seen on the background of the nebula two wide spiral-like spurs, reminiscent of the structure of the inner regions of the N-galaxy 3C 120 and the Sy-galaxy NGC 1068 [23, 24].

Direct proof of the relation of some QSO and N-galaxies with S-systems permits refining the developing evolutionary schemes for quasar-like objects by including in them not only the nuclei of spheroidal, but also plane systems. Seyfert-like systems are the best studied S-galaxies with active nuclei. We will discuss their properties briefly.

III. About 200 Sy-like systems are known at present. Particularly many (about 10%) of them are observed among Markarian objects (Mrk) [24a]. As it has proved [24b], the probability of a Mrk object being a Sy-galaxy increases with increasing optical luminosity. All Sy-galaxies have in their spectra strong, wide emission lines of the Balmer series. Sy-like objects are divided spectroscopically into two basic groups [25], between which there is no sharp boundary [25a]. These are Sy I, for which the total widths of the allowed lines reach several thousand and even ten thousand km/sec, whereas they are only thousands of km/sec for forbidden lines, and Sy II, for which the widths of the allowed lines do not /10

exceed several thousand km/sec and are comparable to the widths of the forbidden lines. It is interesting that the widths of the centers of these lines are about the same for both Sy I and Sy II and the entire difference is related to the very broad wings of the allowed lines in Sy I. Spectroscopic analysis of objects of type Sy I and Sy II has led a number of authors to the conclusion that physical conditions differ greatly in them (for example, [1, 26]). In Sy-galaxies of type I, dense ($n_e \geq 10^8 \text{ cm}^{-3}$) clouds of gas radiate, which are expanding with velocities of several thousand (and sometimes even tens of thousands!) km/sec. Their total mass is not large ($\sim 10^3 M_\odot$) and they are ionized by intense non-thermal emission of the nucleus. It is interesting that the variability in the emission lines lags by several weeks the variability in the continuum [27]^{*)}. This puts a limitation on the dimension of the system of dense clouds of $\ell \leq 10^{18} \text{ cm}$. The parameters of such clouds necessary for shaping logarithmic line profiles are evaluated in work [28] under certain assumptions. The clouds are small:

$d \approx 3 \cdot 10^{13} \text{ cm}$, $M \approx 10^{-8} M_\odot$ and their number reaches 10^{12} . The density of the clouds is much less in Sy ($n_e' \leq 10^3 \text{ cm}^{-3}$, $n_e'' \geq 10^6$), the expansion velocity is much less, while the total mass reaches $\sim 10^7 M_\odot$. They occupy a more extensive region ($r \geq 10^{13} \text{ cm}$). In all probability, the conditions in Sy II are close to the conditions in the region where the forbidden lines are formed in Sy I. There is some evidence for dynamic incoherence of clouds of gas responsible for the appearance of broad wings for the allowed lines and narrow for forbidden lines [29]. Moreover, the conclusion is reached in work [30] that the width of the wings in objects of type Sy I is not related to rapid rotation of the emission region since a sharp cutoff is observed in the distribution of the observed widths of the allowed lines for $V \leq 6000 \text{ km/sec}$.^{**)}

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Although after consideration of dust in Sy II, the fluxes in the $\bar{H}_\alpha$ line are comparable in Sy I and Sy II ($\sim 10^{42} \text{ erg/sec}$), the emission power of forbidden lines in Sy II is 30 times greater than in Sy I, which indicates the low density in the zone of their formation. It is also noted in work [31] that there

*) The problem of the time correlation of the intensities in the lines and in the different regions (radio, optical, X-ray) continuum is extremely important for understanding processes occurring in the nuclei of Sy G. Unfortunately, there are still few observations of this kind.

**) There is at present no unique model of the central region of Sy G which allows understanding of the structure, kinetics and ionization balance in clouds of gas responsible for the observed pattern in the emission lines.

are strong Fe II lines equaling the Balmer lines in width in Sy I, and the decrement, in contrast to Sy II, is not large. The Fe II lines probably arise because of resonance fluorescence in the same region from which the allowed hydrogen lines come. This requires $N_e \approx 10^{23.5} \text{ cm}^{-2}$ in the line of sight, which must blur the optical variability of the nucleus only if the gas is not collected in the disk and the observations are carried out along the poles [31]. In turning to systems of type Sy II, one can reach the conclusion that we have here ionization of gas by the dust-reddened radiation of hot stars. That there is much dust in Sy II is indicated, for example, by the very steep Balmer decrement [26] and the maximum of the emission in the region of 10 (T_v 200 K).

Analysis of the morphological peculiarities of Sy-like objects was carried out in a number of works (for example, [32, 33]). It was found that the fraction of E systems among Sy objects is small (< 5%) and these are, as a rule, Sy II. These are mainly S or Sb galaxies of various types (SO, Sab). No morphological differences have been revealed between Sy I and Sy II.* However, the authors note the interesting fact of the predominant coincidence of similar objects between disturbed and interacting systems. On the other hand, Sy galaxies and generally systems with emission lines in their spectra avoid rich clusters [34, 35].

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The radio properties of Sy G have been discussed by various authors (for example, [36, 37]). Unfortunately, the results of these surveys are difficult to compare because of the differing selections. However, one can note the wide range of radio powers of Sy galaxies (difference of 10^4 times) and their incidence according to this criterion between normal S-galaxies and radio galaxies.

The main radio emission most likely comes from a region $d \approx 100-1000$ pc (the region of emission of forbidden lines). The number distribution of Sy-galaxies over the radio spectral index is practically the same for Sy I and Sy II. In 10% of the cases, Sy-galaxies have nuclear radio sources with flat spectra and time variability. Although it seems that Sy II are more often radioactive, it is shown in [37] that Sy I are more intense RS. It is interesting that $P_r^2 \approx (L_{\text{opt}}^{\text{tot}})^3$ for RS in Sy-galaxies, which is also typical for nuclear RS in radio galaxies.

*) It is noted in work [33a] that S-galaxies of various types generally have the tendency to have peculiar nuclei. This is related to the presence of an intense spherical component in them.

Interesting information has been obtained about neutral hydrogen in Sy-galaxies from the 21 cm radiation [37a]. Of 58 Sy-like systems, line emission is found in 25 and absorption in 3 galaxies. Abnormality of the properties of

HI (large value of $\frac{M_{HI}}{L_{pg}}$, *abs HI*, broad spatial distribution in HI) is noted in

only 30% of the objects. As a rule, bright nuclei and peculiar optical properties (H_α filaments, external HI arcs and rings, etc.) accompany this abnormality. It was found that Sy-galaxies on the average do not differ in the

value of $\frac{M_{HI}}{L_{pg}}$ from the corresponding types of S galaxies, but the disper-

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sion of this quantity is significantly greater for Sy. Among Sy-galaxies are encountered types from S0 to Sb, but almost never E, late S and Ir. Although the value of M_{HI}/L_{pg} reaches 3.3 for Sy II and <0.5 in Sy I, this difference is not related to different amounts of HI in them but to the lesser, on the average, L_{pg} for Sy II. The authors assume [37a] that the phenomenon of Sy nuclei is related to the ejection of gas from stars of the intense spherical component in spiral systems of early morphological type.

Sy-galaxies are rather intense X-ray sources (cf., for example [38, 39]). There are now known about 20 Sy I (10% of the total) radiating about 10^{42-45} erg/sec. in the range 2 - 10 keV. They occupy an intermediate position between QSO and E galaxies with active nuclei. It is interesting that, as a rule, Sy I are strong X-ray sources, although there are exceptions (for example, NGC 3227 and 5506 belong to the type Sy II). A proportionality is noted between the emission intensities of Sy-galaxies in the optical and X-ray ranges, at 21 cm, in the IR and the widths of the Balmer lines. X-ray variability is known in some cases (for example, NGC 4151).

The problem of the difference of S-galaxies with active nuclei of the type Sy and without active nuclei is of interest. While no significant differences in the morphology of these types of galaxies has been found, it is natural to assume that any S-galaxy can have an active nucleus about 1% of the time. However, it is indicated in a number of works that Sy, nevertheless, have significant differences from normal S-galaxies. For example, it was noted in works [40, 41] that Sy G have a steeper gradient of the surface brightness toward the center.

Both the value of the gradient as well as the brightness of the nucleus increase with increasing total luminosity of the galaxy. If these conclusions are confirmed, a lifetime of an active nucleus of $\approx 10^8$ years will not follow then from the fact that Sy G comprise 1% of all S-galaxies. It can be significantly greater depending on the small number of the class of objects differing from initial S galaxies by a greater concentration of luminosity toward the center.

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We have seen that in many of their properties, Sy-galaxies occupy an intermediate position between QSO and other quasar-like objects. Sy-galaxies sometimes occupy even the region occupied by QSO, for example, from their X-ray luminosity or from the luminosity in the H_β [42] line. Some authors have even been led to the conclusion on this basis that QSO are simply remote Sy-galaxies [42, 43, 24b] in which we observe only the bright nucleus.

Speaking of QSO, their spectral characteristics can be classified as Sy I: great line widths and broad region of degree of ionization. The ratio of line intensities $\frac{O\text{IV}}{L_\alpha}$, $\frac{C\text{IV}}{L_\alpha}$, $\frac{He\text{II}}{L_\alpha}$ agrees with the model of photoionization of expanding gas clouds by intense ultraviolet radiation of the nucleus [44]. For close QSO, the type Sy I spectrum is confirmed by broad Fe II lines [45]. As for the spectral peculiarities of other quasar-like objects, it is found that they also can be divided into two types (cf., for example [46, 47]). One type includes RS with broad allowed lines (BLRG); these are the N-galaxies. Their spectral properties resemble Sy I. However, the Fe II are not so broad and the Balmer decrement is steeper (H_α -broad, and H_β -narrow), i.e., this is an intermediate type between Sy I and Sy II.

The other type includes RS identified with optical galaxies of the types cD, DE and simply E with narrower emission lines (NLRG). Their spectra resemble Sy II,

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Having data about the basic properties of quasar-like objects in the optical, radio and X-ray regions, one can turn to the problem of a possible evolutionary scheme for objects with active nuclei.

IV. Attempts to construct evolutionary schemes have been made repeatedly. Of the latter works, one can note [24b, 48, 49]. We will discuss in more detail

those schemes in which is proposed a long time scale for the nuclear activity with possible secondary outbursts occurring on the background of cosmological attenuation of the activity.

Since relativistic particles in weak magnetic fields ($H \sim 10^{-6}$ G) of extended ($\ell > 50$ kpc) components can radiate in the radio range due to the synchrotron mechanism for tens and hundreds of millions of years after an outburst of activity in the nucleus, and evolutionary relation between QSS and other intense radio sources (N-galaxies, radio-galaxies) has been proposed in a number of works [8, 48]. On the other hand, one can propose an evolutionary relation between QSG(E) and E galaxies with active nuclei but without intense radio emission. The evidence that many QSG may not be related to E but to S galaxies permits refining the evolutionary scheme for quasar-like objects considered in [38, 49]. It is natural to assume that the overwhelming fraction of QSS is related to E galaxies and QSG with S systems. It was also determined more accurately in [49] that 75% of QSG are related to bright S-galaxies, whereas several percent of the QSG at most are related to faint S-galaxies. However, this several percent over the number of objects per unit volume constitutes a majority. In general form, the evolutionary scheme of quasar-like phenomena can appear in the following form (evolution in time goes from the spectrum of type 0-I to type II):

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Spectral type*)		Radio properties			
Morphological type		0-I	I	I-II	II
E	QSS ($\sim 10^{-9}$)	?	NGR ($\sim 10^{-7}$)	RG ($\sim 10^{-6}$)	There are extended radio components and nuclear radio components ($P > 10^{43}$ erg/sec)
E	($\sim 10^{-8}$) QSG(E)	($\sim 10^{-7}$) ?	($\sim 10^{-6}$) NG	($\sim 10^{-5}$) EG	Only nuclear RS and weak radio halo active nucleus ($\sim 10^{42}$ erg/sec)
S	($\sim 10^{-7}$) QSG(S)	($\sim 10^{-6}$) Sy I	($\sim 10^{-5}$) Sy I-II	($\sim 10^{-4}$) Sy II	Nuclear RS and emission from the disk ($\leq 10^{42}$ erg/sec)
L_{opt} erg/sec	10^{47-46}	10^{46-45}	10^{45-44}	10^{44-43}	
t yr	$< 10^7$	$\sim 10^8$	$\sim 10^9$	$> 10^9$	

*) Types of optical spectra: 0 - only wide ($\Delta V > 6000$ km/sec) allowed lines for very young objects; I - wide allowed lines and narrower

($\Delta V < 1000$) forbidden lines; II - relatively narrow ($\Delta V < 1000$) allowed and forbidden lines.

**) The approximate spatial density per Mpc^3 at time $Z = 0$ is indicated in parentheses. *)

A number of comments must be made about the proposed scheme.

1) Objects of the type BL Lacertae are not included in the scheme. In our opinion, these objects do not differ from QSO in internal properties. Their observed peculiarities (absence or weakness of emission and absorption lines, large amplitude of variability, compact radio structure) are related to the orientation of their axis of rotation and magnetic field along the line of sight [50, 51].

2) Markarian objects are not included in the scheme [24b]. In fact, these objects are a mixture of galaxies of various types. Those which are Sy-galaxies are included in the scheme. Moreover, there are Mrk objects with condensed bright nuclei under other designations in the scheme (spectral type δ). Thus, only those Mrk galaxies are not included in the scheme, which have a diffuse spectrum (d) and blue color due to outbursts of stellar formation, **) encompassing a region several kpc outside the nucleus (cf., for example [53, 52]). It is interesting that, according to [24b], Sy I, as a rule, belong to type δ , whereas Sy II belong to type d,

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3) The final states of objects, when the activity of their nuclei is cosmologically attenuated, are not indicated in the scheme. It would seem natural to assume that over cosmological times $QSS(E) \rightarrow E$ galaxy, $QSG(E) \rightarrow E$ galaxy, and $QSG(S) \rightarrow S$ galaxy, although the time for achieving the final state may differ for the different types by 2 - 3 times. However, with such an approach, we are ignoring the interaction of the systems with the surrounding medium. Such interaction may significantly change the simple course of the characteristic evolution in activity of nuclei in galaxies of different types.

*) Information is presented in [13] about the optical luminosity function for field galaxies, RG, QSO and QSS. The integral spatial densities are [13]:

$[SyG - 3 \cdot 10^{-5}; RG - 10^{-6}; QSG - 10^{-7}; QSS - 10^{-9}]$ per Mpc^3 .

**) Outbursts of stellar formation outside the nuclear region blur the evolutionary changes in the colors of quasar-like objects. Thus, observations of colors in the nuclear region only are recorded to verify the proposed evolutionary scheme.

V. What is to be understood by the interaction of a system with the surrounding medium if we are interested in the effect of this interaction on the activity of the nucleus? Although there is not yet a final answer to this question, new data have recently appeared about the possible relation between the degree of activity of nuclei and the amount of gas in the system of a given morphological type. Such a relation, for example, is traced for fast galaxies of rich clusters, from which gas is removed by the dynamic pressure of the intergalactic medium [34, 54]. This leads to attenuation of the activity of nuclei in fast galaxies of clusters and, conversely, enhancement of mass in the massive central galaxies. It is not remarkable that precisely this relates to the identification of a majority of strong RG with central systems of clusters and the avoidance of clusters in the current epoch by quasars, N- galaxies, Sy- and Mrk-galaxies and other galaxies with active nuclei (for example, [34, 35]). In earlier epochs, when stellar formation had not yet occurred in systems and there was much gas, it is likely that all these objects including QSO could penetrate into galactic clusters. Thus, it is not remarkable that remote clusters of galaxies or even clusters of QSO are observed around remote QSO. The relation between the amount of gas in the system and the activity of the nucleus is also indicated by the fact that the ratio $\frac{M_{HI}}{M_{tot}} < 10^{-4}$ and $\frac{M_{HI}}{L_B} > 0.01$ in normal E-galaxies with active nuclei (of the type NGC 1052, which is significantly greater than the values typical for E-galaxies: $\frac{M_{HI}}{M_{tot}} < 10^{-4}$ and $\frac{M_{HI}}{L_B} < 0.01$). It is not yet completely clear from where the gas comes in such objects. In principle, it could have been discarded during the evolution of stars in the system itself and collected into the nucleus or have entered the system from the intergalactic medium. It is not excluded that the gas could also overflow from near gas-rich neighbors. Examples of such overflow are well known -- the well-studied pair M81 - M82 in which overflow of gas most likely occurs from M81 to M82 [55, 56]. However, this process must be more significant in S - E pairs, when overflow from S to E must significantly change the observational properties of the E-galaxy. This is evidently the situation in the pair NGC 1052 - NGC 1042 [57]. The increased occurrence of Sy-like objects and Mrk galaxies in pairs and groups of galaxies is of interest from this point of view [58, 32].

It is interesting that the frequency of appearance of radio sources increases in close pairs of galaxies [59], while the dispersion on the two-color (U - B) - (B - V) diagram is large for peculiar galaxies from the Arp catalog

(many of them are interacting) as compared to single galaxies of the same types. This fact is interpreted in [60] under the assumption of induced outbursts of stellar formation in Arp objects.

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All these facts, in our opinion, indicate that the entrance of galaxies into the center of clusters, into pairs or groups of galaxies does not occur without a trace for processes leading, as a final result, to increased activity of the nucleus or to prolonging its active phase. This refers especially to spheroidal systems in which the internal supply of gas must have long since been depleted and a supply of gas to the nucleus from the outside becomes necessary to continue the nuclear activity. This is especially likely since the angular momentum is small in these systems and the concentration of mass near the nucleus is great -- all this aids the rapid influx of gas into the central regions of the galaxy. It would seem that all these arguments could also be applicable to QSO(E) related to E galaxies. If the QSO are nuclei of young gas-rich systems, an external gas source is not necessary for their activity. But, if the QSO are nuclei in old elliptical systems, where the internal gas has already disappeared, then it is necessary to look for an external gas source. (In our evolutionary scheme, this is the problem for objects with $\sim 10^8$ years.) Just as the problem of the search for galaxies around QSO [60a] is of great interest, so too the search for clusters of galaxies near close QSO. For example, a galaxy $m_v = 20.3$ $Z = 0.1575$ [61] was recently observed $75''$ (200 kpc) from the quasar 3C 273 ($Z = 0.158$). The search for normal galaxies near remote QSO is of great difficulty since their visual magnitude cannot exceed 22^m . However, it is not excluded that remote clusters or groups of QSO or at least pairs of QSO would be discovered. Because of the relatively small lifetime of nuclei in the QSO stage ($\sim 10^7$ years), one can expect one such pair per thousand QSO. But the number of identified QSO is just approaching a thousand. A survey of the list of 640 QSO [62] has revealed three possible candidates. To be sure, it is necessary to assume that they are more likely not physical pairs but members of a group of galaxies since ΔV is so large:

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QSO	m_v		$\Delta\delta/\Delta\alpha$	$\frac{\Delta V}{\text{sec}}$ for z	$\Delta\theta_{\min}$ $\Omega=4, H=50$	$M_{\text{exp}}/M_\odot$
0052 + 146	18.2	0.874	$9''/6 \text{ sec}$	3000	4,6 Mpc	10^{16}
0052 + 145	18.3	0.911				
0147 + 090	17.4	0.27	$1''/1 \text{ min}$	6900	350 kpc	5×10^{15}
0148 + 090	17.5	0.30				
0254 - 334	17.0	1.915	$4''/5 \text{ sec}$	6900	41 kpc	6×10^{14}
0254 - 334	16.0	1.849				

There are also not many known pairs of Sy-like objects -- 2 out of 200. This imposes some limitation on the duration of the active phase of the nuclei of Sy-galaxies, although one must not forget that Sy-galaxies may not belong to the class of ordinary S- systems.

CONCLUSION

Thus, on the basis of available observational data on quasar-like objects, one can reach the conclusion about the evolutionary relation between QSS and RG on the one hand; QSG(E) and emission EG and QSG(S) and SyG on the other. Such an evolutionary sequence requires a long time scale (about 10^9 years) for extended radio components of strong RS and definite relationships depending on the lifetime and initial luminosity functions between the spatial densities of quasar-like objects of different types. In particular, the group Sy III must be the most numerous of the Sy-like objects. To be sure, the spatial orientation of these plane systems may have a strong effect on the observational properties of SyG. Even nuclei with a spectrum of the Sy I type in systems observed with an edge because of a great thickness of gas and dust in the disk may acquire some properties of Sy II. /21

The existence of non-radioactive N-galaxies with more active nuclei than for emission EG and an evolutionary transition of the spectral type Sy 0-I into spectral type S II with fading of the non-thermal emission source in the nucleus follow from the proposed scheme. The time for the evolutionary transition of Sy I into Sy II is determined entirely by the characteristic time for the evolutionary decrease in intensity of the ionizing radiation of the nucleus ($\approx 10^7$ years). However, with repeated outbursts in the nuclei, there are also possible more rapid (decades) changes in the spectral types caused both by the ionization and recombination times in the gas clouds as well as the peculiarities of their kinematics and spatial distribution. Thus, the problem of the time variations in the spectra of Sy-like objects and dependence (time shift) of the width and intensities of lines on the intensity of the continuous radiation acquires primary importance for understanding the nature of galactic nuclei (cf., for example [1]).

We note again that the spectral type Sy 0, when there are only wide allowed lines (cf., for example [29]), can probably be observed only in very young objects when the ionizing radiation from the nucleus either has not yet passed through the close dense clouds into the more extended low-density zone or such a zone has not yet been formed. Investigation of quasar-like objects with spectral type Sy 0 (for example PHL 5200, IZw 2130+09, IZw 0051+12) are of great interest.

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TABLE

NEBULAE SURROUNDING QUASI-STELLAR OBJECTS

Object	Z	m_V^R / M_V^R	$m_V^{obs.} / M_V^{obs.}$	Ref.
PHL 1070	0,08	16,6/-20.4		Ap. J. 179, L61 1973
B 264	0,095	16,89/-20.4		
B 340	0,184	16,97/-21.8		
Ton 256	0,131	15,41/-22.42	/-22,43	
1 SC 48	0,367	16,2/-24.3	/-22.8	
PKS 0911+05	0,303	17,4/-23.9		M.N., 182, 361, 1978
0952+09	0,3	18,0/-23.3		
1004+13	0,24	15,2/-25.6		
1049-09	0,34	16,8/-24.8		
1302-10	0,29	15,2/-26.0		
1510-08	0,36	16,5/-25.2		
2135-14	0,20	15,5/-24.9		
SC 79	0,256	19.76	18.93	Ap.J. 180, 687, 1973
109	0,306	19.3	18.23	
120	0,033	14.88/-21	19,92/-18.6	
171	0,238	20.16	19.22	
227	0,085	18.86	16.07	
234	0,185	18.82	19.37	
287.1	0,216	19.83	18.13	
303	0,14	20.04	17.07	
371	0,051	15.78/-21.7	14.25/-20.9	
390.3	0,057	15.73	14.91	
445	0,057	> 17	15.02	
459	0,22	18.85	17.67	
Ton 1542	0,064	/-22.2	-/-21.8	AA, 56, 71, 1977
3C 318	0,752	20.9	21,2/-25.1	Ap. J. 206, 355, 1971.
PHL 1070	0,076	16,6	19.0	$Z_{eff} = 0,067$ Ap. J. 219, 381, 1976

TABLE (Continued)

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Mrk 421	0,03			Ap. J.
Mrk 180	0,046			222, 3,
Mrk II	0,0139			1978
BL Lac *	0,069	/-24.7	/-22.5	Phys. Scip-
Ap. Lib	0,049	/-22.3	/-21.4	ta,
PR S 0548-322	0,069	/-21.6	/-22.0	17, 277,
B2 II01+38	0,031	/-23.5	/-22	78
B2 I652+03	0,034	/-22.2	/-22	MN,
3C 206	0.2	15,5-17,5		184, 335,
				1978
B 154	0,183			
0736+01	0,191			
4C 1.4	0,261			
2135-14	0,202			
3C 323.1	0,264			
3C 244.1	0,311			
3C 249.1 *	0,311			Ap. J. 213,
				8, 1977
AO 0235+164	0,525			Zals
				Ap. J. 218,
				611,
				1977
PR S 0518-45	0,034			PAS P,
! 0521-36	0,061			89, 245,
! 0634-20	0,056			1977
! 1417-19	0,119			
! 2300-18	0,129			
3C 227	0,086			
4C 37.43 *	0,370	15.5		Ap. J.
! E50 II3-	0,045	13/-24		205, 119,
I645				76
				A. R. 12, 113, 12

NOTE: * - Spectra of not only the nucleus but also the surrounding nebula were obtained for these objects.

! - assumed S-galaxies