# STUDIES OF SECOND BYURAKAN SURVEY GALAXIES: II. COMPARISON OF UV-EXCESS AND EMISSION-LINE TECHNIQUES

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## ABSTRACT

The Second Byurakan Survey (SBS) has been defined using two indicators of activity as observed on objective prism spectra: the presence of UV-excess in the continuum (UVX), or the presence of emission lines (EL). Of the $\sim 3500$ objects in the Survey, 1401 are classified as galaxies (Bicay et al. 2000). This paper reports on a comparative study of 524 UVX SBS galaxies and 340 EL SBS galaxies. The parameters used for the comparison were apparent magnitude, redshift, spectral class, luminosity, morphology, activity type, and close environment.

The main results are:

1. In comparison with the UVX method, the EL method allows the creation of a deeper sample of peculiar galaxies. The existence of the emission lines also helps to detect fainter objects among the UVX galaxies.

2. The UVX method covers a larger range of redshifts than does the EL method.

3. 54 AGNs have been discovered with the UVX and 11 with the EL techniques. Among the EL sample objects there are no Seyfert-like galaxies of types Sy1 or Sy1.5. UVX galaxies with AGNs mostly are stellar and semi-stellar spectral classes objects, of which majority are strong or moderate UV-excess emitters.

4. Star-forming galaxies with $z < 0.1$ and discovered via UVX have median luminosity higher than galaxies discovered via EL. The difference is mostly caused by a higher rate of high luminosity (M $\leq -21.0$) galaxies in the UVX sample; these are mostly galaxies with stellar or semi-stellar spectra. Another contribution comes from the higher rate of low-luminosity (M $\geq -17.0$) galaxies in the EL sample, most of which have diffuse or semi-diffuse spectra.

5. UVX and EL active and star-forming galaxies do not show major differences in their distribution of morphological type; in both samples the majority of galaxies are spirals.

6. The UVX and EL samples are similar in their fractions of mergers or interacting systems, as well as the incidence of close pairs or neighbors within r $<$ 50 kpc. However, the UVX galaxies with the strongest excess UV radiation are often in mergers, interacting systems, or close pairs.

7. The EL method allows the creation of a sample with lower apparent magnitudes and higher redshifts among the low luminosity (M $\geq -17.0$) galaxies, and is more efficient at discovering galaxies with compact or irregular morphology.



*Subject headings:* galaxies: surveys – galaxies: statistics – surveys: UV-excess – galaxies: emission line – galaxies: fundamental parameters – galaxies: redshifts – galaxies:


## 1. INTRODUCTION

More than half a century ago the discovery of active galactic nuclei (AGNs) and starburst galaxies heralded a new era in astronomy, an era focusing on the study of the global star formation history of the universe. There is increasing evidence to show that star-forming activity appears to be common in many galaxies at a level sufficient to affect even global properties such as morphological type and luminosity. There is presently much observational information on the phenomena of activity and star formation in galaxies, but the underlying causes of this activity are still poorly understood.

One way to increase our knowledge in this field is through the careful study of larger samples of active and star forming galaxies, samples which may contain objects in different stages of activity, and in different environments both in the local and in the distant universe. Such samples could be defined from existing sky surveys at a variety of observing wavelengths such as the near and far IR (e.g. 2MASS, IRAS), and in the radio (e.g. 5C, 6C) or X-ray range (e.g. ROSAT). However, the most extensive body of knowledge about galaxies exists presently at optical wavelengths, so an optical survey specifically targeting active galaxies would have a large amount of pre-existing information available on which to base comparative studies.

Since the pioneering studies of Haro (1956), Zwicky (1964a,b) and Markarian (1967), many projects have been undertaken to discover large numbers of active and star-forming galaxies at optical wavelengths. Almost all such surveys have been carried out using the wide-field imaging capabilities of Schmidt telescopes and special detection techniques based on some tracer of galaxy activity. Examples of tracers of such activity at optical wavelengths are a relative enhancement of the continuum radiation at UV wavelengths and/or enhanced blue color, and the existence of emission lines from hot gas near active regions.

A discussion of survey methods for finding active and star-forming galaxies and a summary of the major surveys published prior to 1983 are given in the review paper by Kinman (1983). The technique of object selection by their color was introduced by Haro (1956) and requires multiple exposures of the same field through two or three different filters. The largest color-selected sample containing $\sim$ 8200 galaxies was created from the first Kiso survey (Takase & Miyauchi-Isobe 1993, and references therein). A second Kiso photometric survey for UV-excess galaxies is in progress (Miyauchi-Isobe & Maehara 2000). Another survey of this type is the well-known Montreal survey (e.g. Coziol et al. 1997).

The technique of selecting objects according to their excess UV emission on low-dispersion objective-prism *spectra* was introduced by Markarian (1967); we refer to this as the "UVX" method. Objects in the Markarian survey were selected on the criterion that the blue-violet portion of the spectrum is brighter and more extended in wavelength than the red-yellow portion; for A0-A2 stars these two portions (separated by the "green dip") have approximately similar brightness and extension. This survey produced a catalog of 1515 active and star forming galaxies (Markarian et al. 1989). Another survey of UVX galaxies was carried out by Kazarian (1979) with the same telescope and methods as those defined by Markarian (1967).

More recently, the selection of galaxies according to the presence of emission lines in their low-dispersion objective-prism spectra has become popular. We refer to such surveys as "EL" surveys. There are quite a number of these, including the Tololo and Calan-Tololo (Smith 1975; Smith, Aguirre, & Zemelman 1976; Maza et al. 1991), the Michigan survey (UM; MacAlpine, Smith & Lewis 1977; MacAlpine & Williams 1981), the Wasilewski survey (WAS; Wasilewski 1983), the Universidad Complutense de Madrid survey (UCM; Zamorano et al. 1994, 1996; Alonso et al. 1999), and the Hamburg/SAO surveys (e.g. Ugryumov et al. 1999; Pustilnik et al. 1999; Hopp et al. 2000; Kniazev et al. 2001). In very recent times the benefits of objective-prism observations with Schmidt telescopes are being combined with new, more sensitive CCD detectors to provide the means for sensitive new wide-field emission-line surveys (e.g. KISS; Salzer et al. 2000), and we can expect further progress in this field in the future.

The combination of the UVX and EL methods allows the discovery of objects with a broader range of star formation histories and with a larger variety of activity (Surace & Comte 1994). Surveys which use the combined technique to discover active and star-forming galaxies include the Case survey (Pesch & Sanduleak 1983; Stephenson, Pesch, & MacConnell 1992), the Second Byurakan survey (SBS; Markarian, Lipovetsky, & Stepanian 1983; Markarian & Stepanian 1983; Stepanian 1994), and the Marseille Schmidt survey (Surace & Comte 1998).

Several studies have been carried out to compare the different populations of galaxies discovered using different survey techniques. Dennefeld, Karoji, & Belford (1985) and Salzer & MacAlpine (1988) pointed out that some (even a large) portion of galaxies identified as active star-forming galaxies in the IRAS survey are in fact low-excitation galaxies which would not be detected as active or star-forming objects on blue objective-prism surveys. It has also been claimed that color-selected surveys sample a different galaxy population from that selected by emission line surveys (Comte et al. 1994). The color surveys have the advantage of selecting star-forming galaxies in many stages of their evolution, and such surveys pick up the post-starburst galaxies more effectively than UVX samples (e.g. Tomita et al. 1997). EL samples apparently span a broader range of colors and luminosity than UVX samples (Saltzer, MacAlpine & Boroson 1989; Comte 1998). There are also cases where very blue objects in EL samples were "missed" by most well-known Markarian UVX surveys (Saltzer, MacAlpine & Boroson 1989); conversely, only 20% of Markarian galaxies observed in the Wasilewski (1983) EL search were detected as emission line objects. The existence of such "anomalous" cases is not a surprise. During combined UVX and EL surveys, the great majority of discovered objects have emission lines, but only a smaller fraction of them also show UV-excess radiation. But why is this so? Does it depend on observational selection, such as limits on the redshift, apparent magnitude, inclination, or surface brightness of the objects, and/or the limit on equivalent widths for the detection of certain emission lines, and/or the specific set of emission lines used ([OII], H$\beta$ and [OIII], or H$\alpha$, etc.)? Is it also possible that same intrinsic properties of the galaxies, such as morphology, absolute luminosity, internal conditions (dust content, etc.), environment, activity class, stellar population, age of star formation, etc., play some role?

Our goal in this paper is to further illuminate the discussion of the nature and origin of activity in galaxies through comparative study of the properties of a sample of galaxies discovered with a combination of the UVX and the EL methods. Our aim is to clarify possible observational selection effects in the sample, and also to discover any intrinsic differences in the nature of the sample galaxies. To this end we use the Second Byurakan Survey (SBS), which was created using both the UVX and the EL methods. In §2 of this paper the generation of the samples of SBS galaxies discovered with UVX and EL techniques is discussed, and the data are presented. In §3, the results of a comparative study of both samples are given. A discussion and summary is given in §4. Through this paper we have assumed a value for the Hubble constant of $H_o = 75$ km s$^{-1}$ Mpc$^{-1}$.

## 2. THE SAMPLES

Similar to the First Byurakan Survey (FBS; Markarian 1967), the Second Byurakan Sky Survey (SBS; Markarian, Lipovetsky, & Stepanian 1983; Markarian & Stepanian 1983; Stepanian 1994) was carried out with the 1m Schmidt telescope of the Byurakan Observatory in Armenia. In the second survey, each field was observed in three wavelength ranges: in the UV and blue region by a combination of a 1.5° objective prism and IIIaJ plates; in the green region by combination of a 3° prism, a GG495 filter, and IIIaJ plates; and in the red spectral range with a combination of a 4° prism, an RG2 filter, and IIIaF plates. In all cases baked plates were used. With this new instrumental setup the SBS was able to find emission line galaxies (ELGs) up to a limiting magnitude of 19.5. Observations in UV and blue regions have been used to identify UVX objects of any nature (QSOs, galaxies, blue stars, etc.). More than 50% of the ELGs have been selected initially in the red spectral region and have later been checked in the green (Markarian, Stepanian, & Erastova 1987). The SBS plates cover the sky region defined by $7^h\ 40^m < \alpha < 17^h\ 15^m$, $49° < \delta < 61°$, an area of about 1000 square degrees. During this survey about 3500 peculiar objects were identified. Accurate positions for 2978 SBS objects were published recently (Bicay et al. 2000); 1401 of these are considered to be galaxies.

According to Markarian & Stepanian (1983), the SBS selected two types of peculiar galaxies:

1. UVX galaxies with an appreciable and measurable excess of UV continuum radiation; and,

2. EL galaxies without measurable UV emission. These were selected by the presence in the spectrum of emission lines and the absence of a significant UV continuum.

The original SBS lists (Markarian & Stepanian, 1983, 1984a, 1984b; Markarian, Stepanian, & Erastova 1985, 1986; Stepanian, Lipovetsky, & Erastova 1988, 1990) contain 735 extragalactic objects for which coordinates, apparent magnitudes, diameters and spectral classifications are presented. The spectral classification was originally introduced by Markarian (1967) for FBS objects. It describes the degree of concentration of the UV emission as well as its intensity. Emission regions are classified as "stellar" *s* or "diffuse" *d* if the half-width of the emission region on the Schmidt plates is of the order of 2″ or 6–8″, respectively. The intermediate types *sd* and *ds* were also used. A number between 1 and 3 was used to indicate the relative intensity of the UV emission with 1 being the strongest UV excess. The existence of emission lines in the spectra was identified with *e*, and *e:* indicating doubtful cases.

Objects in the SBS lists discovered via the UVX technique have spectral classifications following Markarian (1967). Objects discovered by the EL technique alone have been classified according to the degree of concentration of their continuum radiation. In general, the spectral class of an SBS galaxy contains the following important information:

a) with which technique (UVX or EL) the object has been discovered;

b) whether the spectrum shows emission lines;

c) the degree of compactness of the continuum radiation; and,

d) the strength of the excess UV radiation, if present.

Spectral classes for 864 SBS galaxies are presently available in the literature. Two sub-samples were created; the sub-sample of 524 SBS galaxies discovered via the UVX method ("UVGs" sample, 61% of 864 SBS galaxies with spectral classes), and the sample of 340 SBS galaxies discovered via the EL method ("ELGs" sample, 39% of 864 SBS galaxies with spectral classes). For the objects in each sample the following information has been collected:

- apparent blue magnitudes for all 864 galaxies (Bicay et al. 2000);
- redshifts from the literature and from NED for 490 UVGs and for 269 ELGs (Petrosian et al. 2002);
- morphological classes for all 864 galaxies (Petrosian et al. 2002);
- counts of neighbor galaxies in a 50 kpc circle for galaxies with known redshifts (Petrosian et al. 2002); and,
- activity type (Seyfert, Liner or star forming galaxy).

These data have been used for the comparative study as well as for a detailed study of the SBS UVGs and ELGs samples.

## 3. A COMPARISON OF THE SBS UVGS AND ELGS SAMPLES

We have compared the SBS UVGs and ELGs samples according to the following properties:

- observed parameters such as apparent blue magnitude, and the type of the spectra on the Schmidt plates;
- redshifts from high-resolution spectral observations;
- integral parameters of the galaxies such as absolute magnitude and morphology; and,
- the characteristics of the immediate environment.

Besides a general comparison of the SBS UVGs and ELGs samples, we also examine each sample in detail. We have made a one-dimensional comparison of the data by means of histograms and median values, a two-dimensional comparison, by means of relation between two parameters of the sample(s), and a Multivariate Factor Analysis (MFA).

### 3.1. The SBS UVGs and ELGs samples: Observed Parameters

The apparent magnitude and spectral class of the program galaxies have been determined from Schmidt plate survey material, and the redshift determined from high dispersion spectra of the objects as available in the literature and in NED.

#### 3.1.1. *Apparent Magnitude*

Figure 1a compares the depth of the SBS UVX technique to that of the EL technique in the form of histograms of blue apparent magnitudes for 524 SBS UVGs and 340 SBS ELGs. The median apparent magnitude for SBS ELGs is 17.7, which is 1.1 mag fainter than the median apparent magnitude of SBS UVGs at 16.6. The EL technique apparently allows deeper samples to be constructed, as has been noted previously (Markarian & Stepanian 1983).

Figure 1b compares the histograms of the blue apparent magnitudes for those 297 SBS UVGs, which have stellar (*s*) and semi-stellar (*sd*) spectral classes with the 227 SBS UVGs which have diffuse (*d*) and semi-diffuse (*ds*) spectral classes; the medians are 17.0 and 16.5 respectively. The UVX technique apparently reaches deeper if the source of the UV-excess radiation is stellar or semi-stellar.

A similar comparison of the blue apparent magnitudes of 97 SBS ELGs with *s* and *sd* with 243 SBS ELGs with *d* and *ds* spectral classes (cf. Fig. 1c; median values respectively are equal to 17.0 and 17.5), shows that for the EL technique the "diffuse" spectral class leads to a deeper sample.

Figure 1d presents the histograms of the blue apparent magnitudes for 140 SBS UVGs with strongest (1), and 149 SBS UVGs with faintest (3) UV-excess radiation (medians 17.0 and 16.6, respectively). With the UVX technique, the strength of the UV-excess radiation apparently plays an important role in facilitating the discovery of fainter objects.

#### 3.1.2. *Redshift*

According to Markarian & Stepanian (1983), and Markarian, Stepanian, & Erastova (1987), the UVX technique allows for the selection of peculiar galaxies in the full range of redshifts. On the other hand, the EL technique allows selecting ELGs with $z \leq 0.04$ in the red region of the spectrum, and ELGs with redshifts $0.04 < z \leq 0.1$ in green region.

Accurate redshifts for 759 SBS galaxies with spectral classes are presently available. Figure 2a shows the histograms of the redshifts for 490 UVGs and 269 ELGs. The median redshift for the UVGs is 0.0305, which is larger than the value of 0.0279 for that of the ELGs. Both samples peak at $z = 0.030$; the UVGs sample than shows a smooth fall-off, whereas the ELGs sample falls off fairly quickly at higher $z$. This behavior is a reflection of the limitations of the EL technique in the red region of the spectrum. At the same time, it is interesting to note that 16 ELGs (6% of the sample) have redshifts $z > 0.1$, whereas only 15 UVGs (3% of the sample) have $z > 0.1$. Ten of the 15 high-redshift ELGs are marked as (*e:*) and are doubtful emission-line sources. Both distributions shows minima around $z = 0.020$–$0.025$ and $z = 0.065$.

Figure 2b shows the histograms of redshift for 283 UVGs with *s* and *sd* spectral classes and 207 UVGs with *d* and *ds* spectral classes. The median redshift of *s* + *sd* spectral class UVGs is 0.0315 which is larger than median redshift of 0.0288 for *d* + *ds* spectral class UVGs. We suggest that this difference, as well as the difference between the median redshifts of UVGs and ELGs is related to the nature of the objects, and will be discussed in §4. From these distributions (Fig. 2b) it is obvious that minimum observed near $z = 0.020$–$0.025$ for the total UVGs sample (Fig. 2a) is caused mostly by the *d* and *ds* spectral class UVGs, while the minimum near $z = 0.065$ is caused by *s* and *sd* spectral class UVGs.

Figure 2c shows the redshift histograms for 81 ELGs with *s* and *sd* spectral classes and 188 ELGs with *d* and *ds* spectral classes. The median redshift of *s* + *sd* spectral class ELGs is 0.0284, approximately equal to the median redshift of 0.0279 for the *d* + *ds* spectral class ELGs. The median for the redshifts of both spectral class ELGs are close to the median redshifts for the *d* and *ds* spectral class

UVGs ($z = 0.0288$). This suggests that the difference in the median redshifts of UVGs and ELGs is caused mostly by *s* and *sd* spectral class UVGs.

It is also noticeable that of the 16 ELGs with $z > 0.1$, 15 of them have *d* or *ds* spectral class. These galaxies form a high redshift "tail" of the distribution (Fig. 2c). Both samples contribute to the minimum near $z = 0.025$ in the total redshifts distribution of ELGs (Fig. 2a). On the other hand, the minimum near $z = 0.065$ in total redshift distribution (Fig. 2a) is caused only by *d* and *ds* ELGs.

The redshift distributions for 137 SBS UVGs with strongest (1), and 133 SBS UVGs with faintest (3) UV-excess radiation is shown in Figure 2d. The median redshift of UVGs with strongest UV-excess radiation is 0.0318, which is slightly larger than median redshift 0.0301 of UVGs with the faintest UV-excess radiation. The higher median redshift for UVGs with the strongest UV-excess radiation is caused by the presence of the 11 objects with $z > 0.110$ which form the high redshift "tail" of the distribution (Fig. 2d); without these objects the median redshift of this sample is 0.0304. Both distributions show visible minima near $z = 0.020$–$0.025$ and 0.065.

#### 3.1.3. *Spectral Class*

One of the interesting problems to study is the relation between the degree of concentration of the UV emission and its intensity for the UVGs, as well the degree of the diffuseness of the continuum radiation of ELGs. Among 524 UVGs, 106 (20% of the total) are *s* + *sd* spectral type galaxies which have strong UV-excess radiation, and only 6% of the 524 UVGs (34 objects) are galaxies with strong UV-excess radiation and with *d* + *ds* spectra. The rate of occurrence of UVGs with the faintest UV-excess radiation in *s* + *sd* spectral class is 12% (64 objects from the 524), and in *d* + *ds* spectral class it is 16% (85 objects from the 524). It can be concluded that stronger UV-excess radiation is easier to detect from objects with stellar or semi-stellar spectra. Among 340 ELGs, 97 (29% of the total) are *s* + *sd*, and 243 (71% of the total) are *d* + *ds* spectral class galaxies. This difference of about 2.5 shows that emission lines are easier to detect in objects with diffuse or semi-diffuse spectra.

The use of the 1.5° prism and the IIIaJ plates for the UVX technique provides about 1800 Å mm$^{-1}$ dispersion at H$\gamma$, which permits the detection of several strong emission lines ([OII] 3727, [OIII] 4959/5007, H$\beta$, etc.) in the blue region of the Schmidt spectra. UVGs with emission lines are marked with *e*, and *e:* for doubtful cases.

Of 524 UVGs, 397 (76%) have detected (either well-identified or doubtful) emission lines in their spectra. Of the 397 emission line UVGs, 229 (58%) are *s* and *sd* spectral class, and 168 (42%) are *d* and *ds* spectral class galaxies. The detection rate of emission lines in *s* and *sd* spectral class UVGs is 77% (229 from a total of 297), and in *d* and *ds* spectral class galaxies it is 74% (168 from a total of 227).

The median apparent magnitude for 127 UVGs with no detected emission lines in their Schmidt spectra is 16.5, which is brighter than the median apparent magnitude of 17.0 for 397 UVGs with detected emission lines. This means that the existence of emission lines in the Schmidt spectra helps to define a deeper sample of peculiar galaxies with UV-excess radiation. At the same time, the median apparent redshift of UVGs with no detected emission lines in their Schmidt spectra is 0.0327 (N = 113 galaxies), which is higher than median redshift 0.0301 (377 galaxies) for UVGs with detected emission lines. The higher median redshift for UVGs with no detected emission lines is caused by *s* and *sd* spectral class UVGs with a median redshift of 0.0382, and especially those galaxies with the strongest UV-excess radiation among them (the median redshift of which is 0.0752).

About 30% of galaxies detected via EL technique have been marked as objects with doubtful emission lines. This sample of ELGs has median apparent magnitude 18.0 and median redshift of 0.0295, differing from the median apparent magnitude and redshift (17.5 and 0.0271 respectively) of ELGs with well detected emission lines. The reason for this seems obvious: emission lines are easier to detect in galaxies which are brighter, and those closer will also generally be brighter.

### 3.2. The SBS UVGs and ELGs Samples: Derived Parameters

We now discuss the derived parameters: activity type, luminosity, morphology, and local environment of the sample galaxies. We also give special attention to the dwarf (M $\geq -17.0$) SBS galaxies. We begin by examining the properties of the UVGs and ELGs with AGNs. These objects will then be eliminated from the subsequent statistical analysis. This means that luminosity, morphology, and local environment will be discussed only for the sample of star forming SBS galaxies.

#### 3.2.1. *Activity Type*

The number of AGNs discovered among the SBS galaxies is presently 98, of which 65 galaxies have spectral classes determined. From these 65 AGNs, 54 (83%) have been discovered via UVX technique and 11 (17%) via the EL technique. Among 54 UVGs with AGNs, the distribution of the types of activity is as follows: Sy1 – 24; Sy1.5 – 6; Sy2 – 15; Liner – 4 and suspected AGNs – 5. Among the

11 ELGs with AGNs there are no Sy1 or Sy1.5 type objects. Eight AGNs are Sy2, two are Liners and one is a suspected AGN. 78% (42 from 54) of UVGs with AGNs are of *s* or *sd* spectral classes, of which 95% (40 from 42) are strong (1) or moderate (2) UV-excess emitters. From 12 UVGs with AGNs of *d*+ *ds* spectral classes, 10 (83%) are Sy2, Liners or suspected AGNs. In the population of Sy2, Liners or suspected AGNs among UVGs with AGNs, the rate of *d* + *ds* spectral class objects is 42% (10 out of 24 Sy2, Liners and suspected AGNs). In the sample of ELGs with AGNs (which contains only Sy2s, Liners and suspected AGNs), the rate of *d* + *ds* spectral class objects is 73% (8 out of 11). The median redshift of UVGs with AGNs is 0.0500 and the median apparent magnitude is 16.5. The median redshift and apparent magnitude of UVGs which are Sy2s, Liners, and suspected AGNs are 0.0424 and 16.5 respectively. The median redshift of ELGs with AGNs is 0.0328 and their median apparent magnitude is 16.3. In spite of small number of examined AGNs it is obvious that closer distances and brighter apparent magnitudes of ELGs with AGNs make it easier to identify diffuse and semi-diffuse emission line regions in these objects.

In order to avoid a possible Malmquist bias effect we exclude from the current and following statistics all SBS objects with the redshifts of $z \geq 0.1$. For 44 UVGs with AGNs and with redshifts $z < 0.1$ the median absolute magnitude is −20.6, which is 0.4 magnitudes brighter than median absolute magnitude (−20.2) of 11 ELGs with AGNs (among these galaxies there are no objects with $z \geq 0.1$). Since the median apparent magnitudes for both samples of galaxies are equal to 16.3, the slightly higher median luminosity of UVGs with AGNs is caused by their larger median redshift (0.0425) compared to the median redshift (0.0328) of ELGs with AGNs. There are no obvious differences between the median luminosities of the sub-samples of UVGs and ELGs with AGNs which are extracted from the main samples according to the compactness of the spectra, or the presence or absence of emission lines, or the strength of the UV-excess radiation. In both samples of galaxies with AGNs, spirals are in the majority (57% of UVGs with AGNs, and 73% of ELGs with AGNs). The remaining galaxies are classified as Compact (respectively 16% and 18% of UVGs with AGNs, and ELGs with AGNs) and S0 (respectively 16% and 9% of UVGs with AGNs, and ELGs with AGNs) morphological types. Five (11% of 44) UVGs with AGNs are classified as mergers or strong interacting systems. There are no such systems among ELGs with AGNs.

#### **3.2.2.** *Luminosity*

Absolute magnitudes are computed using apparent magnitudes listed by Bicay et al. (2000) and redshifts available in the literature and in the NED according to the relation:

$$M_{\rm pg} = m_{\rm pg} - 5 \times \log(z) - 43.01 - 0.24 \times csc(b'') \ ,$$

where the last term is a correction for Galactic absorption. We compare the luminosities of the star forming UVGs with those of the star forming ELGs in Figure 3a. The median absolute magnitude of the UVGs is −19.2, which is 0.6 magnitudes brighter than the median absolute magnitude −18.6 of the ELGs. Intermediate-luminosity galaxies dominate both samples. The population of high-luminosity objects (M $\leq$ −21.0) in the UVG sample is about twice (6% of 431 UVGs) that of the ELG sample (3% of 242 ELGs). The population of low-luminosity galaxies (M $\geq$ −17.0) in the ELG sample is larger (20% of 242) than in the UVG sample (16% of 431).

Figure 3b plots the histograms of absolute magnitude for UVGs with *s* + *sd* and *d* + *ds* spectral classes. The median absolute magnitude of *s* + *sd* spectral class UVGs is −19.3, and median absolute magnitude of the *d* + *ds* spectral class UVGs is −19.0. For the low and intermediate luminosity ranges the distributions of both samples are similar. In the higher luminosity regions the distribution of *d* and *ds* spectral class UVGs decreases rapidly, leading to a lower median luminosity of these galaxies.

Figure 3c presents the histograms of absolute magnitude for the *s* + *sd* and *d* + *ds* spectral class ELGs. The median absolute magnitude of *s* + *sd* spectral class ELGs is −19.4, which is 1.0 magnitudes brighter than median absolute magnitude −18.4 of *d* + *ds* spectral class ELGs. The sample of *d* + *ds* spectral class ELGs is dominated by intermediate luminosity galaxies, which are 77% of its population. 19% of the sample galaxies are of low luminosity, and remaining 4% are high luminosity objects. The rates of low and high luminosity galaxies (19% and 3% respectively) in the sample of *s* + *sd* spectral class ELGs are approximately similar to those for the sample of *d* + *ds* spectral class ELGs. The higher median luminosity (1.0 mag) of *s* + *sd* spectral class ELGs is caused by the larger population (52% of 77 sample galaxies) of galaxies in the −19.0 to −21.0 range of absolute magnitude. Only 33% of 165 *d* + *ds* spectral class ELGs populate the same absolute magnitude range.

The absolute magnitude distributions for 103 SBS UVGs with the strongest (1), and the 125 SBS UVGs with the faintest (3) excess UV radiation is shown in Figure 3d. The median absolute magnitude of UVGs with the strongest excess UV radiation is −18.5, which is 1.1 magnitudes fainter than the median absolute magnitude of −19.6 for UVGs with the faintest excess UV radiation. The population of low luminosity galaxies (M $\geq$ −17.0) in the sample of UVGs with the strongest excess UV radiation is about 3.5 times (21% of 103) that of the sample of UVGs with the faintest excess UV radiation (6% of 125). This large difference is mostly responsible for the fainter median luminosity of the sample of UVGs with the strongest excess UV radiation.

The median absolute magnitude of 99 UVGs with no detected emission lines in their objective prism spectra is −19.7, which is 0.7 magnitudes brighter than the median absolute magnitude −19.0 of 330 UVGs with detected emission lines. Figure 3e plots absolute magnitude histograms for both samples of UVGs. The frequency of occurrence of low luminosity galaxies (M $\geq -17.0$) in the sample of UVGs with no detected emission lines is about a factor 3 lower (about 6% of 99) than that of these galaxies in the sample of UVGs with detected emission lines (18% of 330); however, this is not the main cause of the difference in the median absolute magnitudes; rather, an excess of intermediate luminosity galaxies in the sample of UVGs with no detected emission lines plays a crucial role.

#### **3.2.3.** *Morphology*

The morphology of galaxies has long been regarded to be an important tool for understanding galaxy formation and evolution. A morphological study of SBS galaxies has been carried out on the digitized $F$ and $J$ band images extracted from photographic plates obtained for the Second Palomar Observatory Sky Survey (POSS-II). We classify SBS galaxies within the sequence E-S0-S-Im and the extension for Blue Compact Dwarf Galaxies (BCDGs, Sandage & Binggeli 1984). Compact galaxies form a special class of objects. Mergers, interacting systems, and close pairs of SBS galaxies have been studied previously (Petrosian et al. 2002). Here we compare the morphological properties of the SBS UVGs and ELGs samples and sub-samples.

From 864 SBS galaxies with determined spectral classes, only one object (SBS1652+574 = Mkn889) has been classified as an elliptical galaxy, 6 objects are giant HII regions in their host galaxies (Petrosian et al. 2002), 73 objects are mergers, interacting systems or peculiar galaxies (Petrosian et al. 2002), and the remaining 784 have been classified as compact, S0, spiral, irregular and BCD type galaxies. 704 of the 784 are objects without AGNs, and with redshifts of $z < 0.1$. From these 704 galaxies, 420 are UVGs and 284 are ELGs.

We compare the distributions (in %) of compact, S0, spiral, Im and BCD morphological type galaxies in UVGs and ELGs samples in Figure 4. Figure 4 reveals that there are no large differences in the morphological type distributions of the UVGs and ELGs samples. In both samples spiral galaxies are in the majority.

Figure 5a plots the distributions (in %) of compact, S0, spiral, Im and BCD morphological type galaxies for UVGs in all spectral classes. Figure 5a shows that:

- in general, spiral galaxies are in the majority (except for the two classes *sd1* and *s1* in which compact galaxies are in majority);
- the highest rates of occurrence of spiral galaxies are in the *d3, ds3* and *sd3* spectral classes, which are characterized by the faintest (3) UV-excess radiation;
- the lowest rates of occurrence of spiral galaxies are in the *d1, ds1, sd1* and *s1* spectral classes, which are characterized by the strongest (1) UV-excess radiation;
- in all spectral classes (*d, ds, sd* and *s*) the highest rate of compact galaxies occurs for objects with the strongest (1) UV-excess radiation;
- the lowest rates of occurrence of compact galaxies are in spectral classes *d3, ds3, sd3, s2 and s3*, with generally the faintest (3) UV-excess radiation;
- the rate of occurrence of S0 galaxies slightly increases along the sequence from diffuse to stellar spectral class;
- irregular galaxies with diffuse spectra and with moderate and strong UV-excess radiation (*d*1 and *d*2) are very common; and,
- the highest rate of occurrence of BCD galaxies is in the *d1* spectral class, which is characterized by diffuse spectra and the strongest UV-excess radiation.

The distributions (in %) of compact, S0, spiral, Im and BCD type galaxies for ELGs in all spectral classes are shown in Figure 5b. This figure shows that:

- compact galaxies are slightly more common among galaxies with stellar spectra;
- in all spectral classes spiral galaxies are in the majority. Their rates of occurrence decrease along the sequence diffuse to stellar spectral classes;
- the rate of occurrence of S0 galaxies increases along the sequence diffuse to stellar spectral class;
- the rate of occurrence of irregular galaxies decreases along the sequence diffuse to stellar spectral class; and,
- in all spectral classes the rate of occurrence of BCD galaxies is approximately constant.

Figure 6 shows the rates (in %) of spiral ELGs and UVGs with the strongest excess UV radiation in all spectral classes (*d, ds, sd* and *s*). It is obvious that the rate of occurrence of spiral UVGs with the strongest UV-excess radiation increases with increasing compactness of the UV radiating region, and rate of ELGs decreases with increasing compactness of the emission line region.

#### 3.2.4. *Close Environment*

There is convincing evidence that interactions between galaxies triggers extranuclear as well as central star formation and/or AGN activity (e.g. Kennicutt, Schweizer, & Barnes 1998). However, a one-to-one correlation between galaxy-galaxy interactions and star formation is not obvious. The problem remains, and any new study in this field adds more information for understanding the role of interactions as a trigger of star formation and/or nuclear activity in galaxies.

In the first paper of this series (Petrosian et al. 2002) we presented the samples of 110 SBS galaxies in 102 mergers, 58 SBS galaxies in 47 interacting systems, and 49 SBS galaxies in 30 close pairs. We compared the rates of UVGs and ELGs in these samples as well as counts of neighboring galaxies inside a circle of 50 kpc radius around UV or EL galaxy. The total number of UVGs with star forming activity in the samples of SBS mergers, interacting systems and close pairs is 67 (60% of total 112 star forming SBS galaxies with spectral classes in these samples). The remaining 45 objects are ELGs. The rates of occurrence of UVGs and ELGs in mergers, interacting systems and close pairs are similar to the rates of UVGs and ELGs in the total sample of 799 star forming SBS galaxies with spectral classes (61% and 39% respectively). The number of UVGs with the strongest UV-excess radiation in the samples of SBS mergers, interacting systems and close pairs is 24 (36% of total 67 UVGs in these samples). This rate is significantly higher than the rate of similar galaxies in the total sample of UVGs (23%, 106 of the 470 UVGs are objects with the strongest UV-excess radiation).

For all SBS galaxies which have determined redshifts, the results of the counts of neighboring galaxies inside a circle of 50 kpc radius is available (Petrosian et al. 2002). All galaxies detected within this circle were counted if their angular sizes differed from that of the SBS galaxy by no more than factor of 2. In order to suppress the undue influence of the Local Supercluster as well as possible selection effects related to the angular size of the galaxies, we have here restricted the SBS sample to include only galaxies with heliocentric velocities larger than 3000 km $s^{-1}$. There are 579 objects in this restricted sub-sample from a total of 799 SBS galaxies with spectral classes; of this 579 objects, 368 are UVGs and 211 are ELGs. Among these galaxies 114 (31% of 368) of the UVGs and 62 (29% of 211) of the ELGs have one or more neighbor(s) inside the 50 kpc circle. Among 114 UVGs with one or more neighbor(s) inside of 50 kpc circle, 30 (26%) are galaxies with the strongest UV-excess radiation. The number of UVGs with the strongest UV-excess radiation in the total sample of restricted redshift range UVGs is 81 (22% of 368).

#### 3.2.5. *Dwarf ($M \geq -17$) Galaxies*

During the last decade, special attention has been paid to the low luminosity sub-sample of SBS galaxies (e.g. Pustilnik et al. 1995, 2001, Thuan et al. 1999); this is mostly due to the number of interesting galaxies in this sub-sample, such as SBS0335−052, which is nearly as metal-poor as IZw18 (e.g. Kunth & Ostlin 2000).

The number of dwarf galaxies among UVGs is 68 (59% of the total dwarf sample) and among ELGs it is 47 (41% of the total dwarf sample). The rates of dwarf UVGs and ELGs are similar to the rates of star forming UVGs and ELGs in the total sample of 799 such SBS galaxies with spectral classes (59% and 41% respectively). This means that the identification of SBS galaxies either via UVX or EL technique does not depend on the galaxy luminosity, but operates in the same way for dwarfs as well as for the total star forming SBS sample.

The median apparent magnitude of 18.0 for the dwarf ELGs is lower and their median redshift of 0.0099 is higher than the median apparent magnitude of 17.0 and redshift 0.0077 of dwarf UVGs. The median absolute luminosity of −16.0 for the dwarf ELGs is slightly higher than the median absolute luminosity −15.6 of dwarf UVGs. The EL technique is apparently somewhat more effective than the UVX technique in creating a deeper sample of low luminosity objects.

The number of $d$ + $ds$ spectral classes galaxies among dwarf UVGs is 37 (54% of 68) and among dwarf ELGs is 32 (68% of 47). The dwarf ELGs are more often diffuse and semi-diffuse galaxies than is the case with the dwarf UVGs.

The number of dwarf UVGs with strongest UV-excess radiation is 22 (32% of 68); the number of dwarf UVGs with faintest UV-excess radiation is only 9 (13% of 68).

Figures 7a and b compare the rates (in %) of the dwarf and total samples star forming UVGs and ELGs among compact, S0, spiral, irregular and BCD galaxies. Among the compact SBS galaxies, the discovery rate of dwarf ELGs is approximately twice the rate in the total sample (59% versus 30%). Among the irregular SBS galaxies, the discovery rate of dwarf ELGs is approximately 1.6 times the rate in the total sample (43% versus 27%). This means that the EL technique is more efficient for discovering compact and irregular dwarf galaxies. For other morphological types this is less obvious. Among the compact SBS galaxies, the high redshift and high luminosity objects generally lead to higher discovery rates in the total sample of UVGs.

### 3.3. Multivariate Factor Analysis

For the further exploration of the data related to the UVGs and ELGs we have used the Multivariate Factor Analysis (MFA) method. This is a statistical method for detecting correlations among a set of $m$ initial variables measured on $n$ objects through a reduced number $p < m$ of linearly independent factors *F1, F2, . . . Fp* that account for the correlation. A detailed description of the MFA method can be found in Harman (1967) and Afifi & Azen (1979). This method has been used in astronomy by several authors (e.g. Petrosian & Turatto 1992; Patat et al. 1994).

The MFA method is applied to the sample of 625 spectrally classified SBS galaxies with redshifts in the range of $0.01 < z < 0.1$. For the analysis of this sample we choose as initial variables the spectral class *SC*, with $SC = 1$ for galaxies discovered with the UVX technique and $SC = 2$ for galaxies discovered with the EL technique; the compactness $C$ of the UV (for UVGs) or continuum (for ELGs) emission region, with $C = 1$ for galaxies with "stellar" $s$, $C = 2$ for galaxies with "semi-stellar" *sd*, $C = 3$ for "semi-diffuse" *ds* and $C = 4$ for "diffuse" $d$ class spectra; the relative intensity $UV - ex$ of UV-excess radiation or its absent, with $UV - ex = 1$ for strongest, $UV - ex = 2$ for intermediate, $UV - ex = 3$ for faintest UV-excess radiation, and $UV - ex = 4$ for the cases when UV-excess radiation absent; the apparent photographic magnitude $m_{\rm pg}$; the redshift $z$; the absolute photographic magnitude $M_{\rm pg}$, the morphological type $T$, with Elliptical/Compact type = 0, S0 = 1, Spiral = 2; Irregular = 3, BCD = 4 and Mergers/Interacting Systems = 5; the number counts of galaxies inside a 50 kpc circle $N_{50}$; the membership of the merger, interacting system or close pair *Int*, with $Int = 1$ for the members of such systems and 0 if not; and a parameter $AGN$ for nuclear activity with $AGN = 0$ for normal and 1 for active nuclei. In order to present each initial variable with the smaller number of common factors for an easier interpretation of the results, we apply the Varimax orthogonal rotation to four factors.

In Table 1 the Varimax rotated factor scores and the accumulated dispersions of the first four factors are presented, for a total of 70% of the common variance. Factor scores are the correlation coefficients between the initial variables and the factors. Adopting a correlation threshold of r ≈ 0.7 we find that the first factor $F1$ correlates the spectral class with the relative intensity of the UV-excess radiation, i.e. stronger UV-excess radiation objects were discovered via UVX method, which is obvious. Factor $F2$ correlates the morphological type of SBS galaxies with their membership in interacting systems. Since for galaxies in interaction we adopt highest morphological class ($T = 5$) this correlation is also obvious. The third factor, $F3$, correlates the redshift and absolute magnitude of the galaxies, with higher redshift galaxies having higher luminosity, a well-known result for all galaxies. Factor four, $F4$, depends only on apparent photographic magnitude of SBS galaxies. With r = 0.2–0.6 correlation threshold we can confirm some results obtained in the previous sections and also note a few new ones. The strength of the UV-excess radiation correlates with the compactness of the emitting region. Stronger UV-excess radiation is easier to discover from the more compact regions (§3.1.3.). The UVX method in comparison with the EL method is better tool to discover galaxies with AGNs (§3.2.1.). Compactness of the emitting region also helps to identify such a objects (§3.2.1.). Factor three, $F3$, correlates activity type ($AGN$) of the SBS galaxies on the level of −0.392. With this correlation threshold we confirm the obvious findings, that high redshift and luminosity galaxies are more likely to have AGNs. The same factor correlates the neighbor counts inside a 50 kpc circle ($N_{50}$) on the level of 0.575. This may be a selection effect: around high redshift SBS galaxies it is harder to identify diffuse objects with diameters smaller than the SBS galaxy itself.

## 4. DISCUSSION AND CONCLUSIONS

The results presented in the preceding paragraph indicate that the use of the combined UVX and EL techniques in the Second Byurakan Survey has led to the discovery of active and star-forming galaxies with a broad range of observed and derived parameters.

Both the UV-excess and the EL techniques are designed to discover active and star forming galaxies. The populations of galaxies discovered with these two methods will in general be quite similar, but some differences of detail may be expected. The occurrence of AGN-like nuclear activity and the appearance of large numbers of massive hot stars can both lead to the production of excess UV radiation and emission lines. In starburst galaxies the equivalent width of the principal emission lines has a general tendency to increase with the UV-excess radiation (e.g. Comte et al. 1994). However, the emission lines could be of small equivalent width in AGNs because of the strong continuum radiation, and such objects would be very difficult to detect. Further-more, as a starburst ages, the most massive stars will disappear and it may become difficult to detect the excess UV radiation. Observational difficulties may also play a role; for instance, detection of the UV-excess radiation can be problematic if there is no appropriate level of continuum surface brightness in the visible and blue regions of the spectrum to provide a comparison. Such a low level of continuum can be a consequence of intrinsic properties, such as the particular stellar population of the galaxy, or observational limits, such as a large angular size. The detection of emission lines can also be problematic, for instance if the contrast between the continuum and the strongest emission lines is too small. A high continuum level, coupled with weak emission lines, can adversely affect the identification of an active galaxy with the EL technique (Kinman 1983). On the other hand, star forming regions with very faint continuum can be selected by the presence of emission line features. Finally, the apparent magnitude and the redshift can both play crucial roles in the selection of survey galaxies.

In the light of these expected similarities and differences between the two observational techniques, we can understand the results of this paper as follows:

1. In general, the EL technique allows the creation of deeper samples of peculiar galaxies than does the UVX technique. The presence of emission lines also helps in the detection of fainter objects among UV-excess galaxies. With the UVX technique, the detection of fainter galaxies is easier if they have stellar or semi-stellar spectra and stronger UV-excess radiation. On the other hand, with the EL technique, the "diffuseness" of the spectra helps to create a deeper sample of galaxies. Fainter apparent magnitude and/or diffuse spectra galaxies have low surface brightness, and this makes the detection of emission lines on objective prism spectra more easier (Kinman 1983). Faint galaxies with stellar spectra and strong UV-excess radiation have enough surface brightness in their spectra to be detected as UV-excess objects.

2. The UVX technique covers a larger space of redshifts than does the EL technique. This is caused mostly by the presence of stellar and semi-stellar spectra among the UVGs; there are in general high luminosity Seyfert-type galaxies. These galaxies are mostly those UVGs with the strongest UV-excess radiation; they are similar in their properties (redshift, luminosity and stellar type of spectra) to the SBS star-like AGNs and QSOs (Stepanian 1993), which are included in the list of 1577 star-like objects of Bicay et al. (2000). Among the higher redshift Seyfert UVGs a few objects have detected emission lines in their prism spectra (Erastova 2000). These objects make a large contribution since UVGs without detected emission lines have a higher median redshift than those UVGs with emission lines.

3. 54 AGNs (30 Sy1s/Sy1.5s, 19 Sy2s/Liners, and 5 suspected Sys) have been discovered with the UVX technique and 11 with the EL technique (8 Sy2s, 2 Liners, and 1 suspected Sy). The majority of these are spiral galaxies which have stellar or semi-stellar spectra with strong or intermediate UV-excess radiation.

4. Star-forming galaxies discovered with the UVX technique have higher median luminosities than galaxies discovered via EL technique. This difference is caused mostly by the higher incidence of high luminosity ($M \leq -21.0$) galaxies among UVGs (these are generally galaxies with stellar or semi-stellar spectra, often without detectable emission lines), and also by the higher rate of low luminosity ($M \geq -17.0$) galaxies among the ELGs (which mostly have diffuse and semi-diffuse spectra). Low luminosity UVGs frequently have strong UV-excess radiation.

5. Star forming galaxies discovered with the UVX and EL techniques do not show major differences in their distribution of morphological types. In both samples, spiral galaxies are in the majority. Spirals discovered with the UVX technique are usually not the brightest UV-excess emitters, but the strength of their UV-excess radiation increases with the degree of compactness of the emission region. The frequency of spiral galaxies discovered with the EL technique slightly decreases along the sequence from diffuse to stellar spectra. Compact UV-excess emitters in spiral galaxies mostly coincide with their nuclei. Among UV-excess spirals the numbers of the galaxies with diffuse and stellar spectra are approximately equal. UV-excess compact galaxies mostly have stellar or semi-stellar spectra and generally are the strongest UV-excess emitters. The frequency of S0 UV-excess as well as emission line galaxies increases slightly along the sequence of galaxies with diffuse to more stellar spectra. The UV-excess irregular galaxies discovered with the UVX and EL techniques mostly have diffuse and semi-diffuse spectra and, if they are UV-excess emitters, they generally have strong to intermediate UV-excess radiation. The highest incidence of BCDs is among those galaxies with diffuse spectra and with the strongest UV-excess radiation.

6. Although 67 of the UV-excess and 45 of the EL star forming galaxies are mergers, interacting systems, or members of close pairs, most galaxies discovered with these techniques are isolated; they do not even have a close neighbor within a circle of r < 50 kpc. Mergers, interacting systems and close pairs do, however, include those galaxies with the strongest UV-excess radiation.

7. The EL technique leads to low-luminosity galaxy samples (M $\geq -17.0$) which are fainter and have higher redshifts, and facilitates the discovery compact or irregular morphology galaxies with diffuse or semi-diffuse spectra. The low luminosity galaxies discovered with the UVX technique are generally the strongest UV-excess emitters.

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## REFERENCES


Afifi, A. A., & Azen, S. P. 1979, Statistical Analysis. A Computer Oriented Approach, Academic Press, Chicago

Alonso, O., Garcia-Dabo, C. E., Zamorano, J., Gallego, J., & Rego, M. 1999, ApJS, 122, 415

Bicay, M. D., Stepanian, J. A., Chavushyan, V. H., Erastova, L. K., Ayvazyan, V. T., Seal, J., & Kojoian, G. 2000, A&AS, 147, 169

Comte, G. 1998, Astrophysics, 41, 89

Comte, G., Augarde, R., Chalabaev, A., Kunth, D., & Maehara, H. 1994, A&A, 285, 1

Coziol, R., Demers, S., Berneoud, R., & Peòa, M. 1997, AJ, 113, 1548

Dennefeld, M., Karoji, H., & Beldford, P. 1985, in Star Forming Dwarf Galaxies and Related Objects, eds. D. Kunth, T. X. Thuan, & J. T. T. Van (Paris, Editions Frontieres), 351

Erastova, L. K. 2000, Astrophysics, 43, 141

Harman, H. H. 1967, Modern Factor Analysis (2nd edition), Univ. of Chicago Press, Chicago

Haro, G. 1956, Bol. Obs. Tonantzintla y Tacubaya, 14, 8

Hopp, U., Engels, D., Green, R. F., et al. 2000, A&AS, 142, 417

Kazarian, M. A. 1979, Astrophysics, 15, 1

Kennicutt, R. C., Jr., Schweizer, F., & Barnes, J. E. 1998, Galaxies: Interactions and Induced Star Formation (Berlin: Springer)

Kinman, T. D. 1983, in Astronomy with Schmidt-type Telescopes, IAU Colloq. #78, ed. M. Capaccioli), 409

Kniazev, A. Yu., Engels, D., Pustilnik, S. A, et al. 2001, A&A, 366, 771

Kunth, D., & Ostlin, G. 2000, A&ARv, 10, 1

MacAlpine, G. M., Smith, S. B., & Lewis, D. W. 1977, ApJS, 34, 95

MacAlpine, G. M., & Williams, G. A. 1981, ApJS, 45, 113

Markarian, B. E. 1967, Astrophysics, 3, 34

Markarian, B. E., Lipovetsky, V. A., Stepanian, J. A. 1983, Astrophysics, 19, 14

Markarian, B. E., Lipovetsky, V. A., Stepanian, J. A., Erastova, L. K., & Shapovalova, A. I. 1989, Comm. Spec. Astrophys. Obs., 62, 5

Markarian, B. E., & Stepanian, J. A. 1983, Astrophysics, 19, 354

Markarian, B. E., & Stepanian, J. A. 1984a, Astrophysics, 20, 10

Markarian, B. E., & Stepanian, J. A. 1984b, Astrophysics, 20, 278

Markarian, B. E., Stepanian, J. A., & Erastova, L. K. 1985, Astrophysics, 23, 623

Markarian, B. E., Stepanian, J. A., & Erastova, L. K. 1986, Astrophysics, 25, 551

Markarian, B. E., Stepanian, J. A., & Erastova, L. K. 1987, in Observational Evidence of Activity in Galaxies, IAU Symp. 121, eds. E. Ye. Khachikian, K. J. Fricke, & J. Melnick (Dordrecht: Reidel), 25

Maza, J., Ruiz, M. T., Gonzalez, L. E., Wischnjewsky, M., & Peòa, M. 1991, A&AS, 89, 389

Miyauchi-Isobe, N., & Maehara, H. 2000, Publ. Natl. Astron. Obs. Japan, 6, 1

Patat, F., Barbon, R., Cappellaro, E., & Turatto, M. 1994, A&A, 282, 731
Pesch, P., & Sanduleak, N. 1983, ApJS, 51, 171
Petrosian, A. R., & Turatto, M. 1992, A&A, 261, 433
Petrosian, A., McLean, B., Allen, R., Leitherer, C., MacKenty, J., & Panagia, N. 2002, AJ, 123, 2280
Pustilnik, S. A., Engels, D., Ugrumov, A. V., et al. 1999, A&AS, 135, 299
Pustilnik, S. A., Kniazev, A. Y., Lipovetsky, V. A., & Ugrumov, A. V. 2001, A&A, 373, 24
Pustilnik, S. A., Ugryumov, A. V., Lipovetsky, V. A., Thuan, T. X., & Guseva, N. G. 1995, ApJ, 443, 499
Salzer, J. J., Gronwall, C., Lipovetsky, V. A., et al. 2000, ApJ, 120, 80
Salzer, J. J., & MacAlpine, G. M. 1988, AJ, 96, 1192
Salzer, J. J., MacAlpine, G. M., & Boroson, T. A. 1989, ApJS, 70, 447
Sandage, A., & Binggeli, B. 1984, AJ, 89, 919
Smith, M. G. 1975, ApJ, 202, 591
Smith, M. G., Aguirre, C., & Zemelman, M. 1976, ApJS, 32, 217
Stepanian, J. A. 1993, in Astronomy from Wide-Field Imaging, IAU Symp. #161, eds. H. T. MacGillivray, E. B. Thomson, B. M. Lasker, I. N. Reid, D. F. Malin, R. M. West, & H. Lorentz, (Dordrecht: Kluwer), 731
Stepanian, J. A. 1994, Doctoral thesis, Spec. Astrophys. Obs., Nizhnij Arkhys
Stepanian, J. A., Lipovetsky, V. A., & Erastova, L. K. 1988, Astrophysics, 29, 552
Stepanian, J. A., Lipovetsky, V. A., & Erastova, L. K. 1990, Astrophysics, 32, 252
Stephenson, C. B., Pesch, P., & MacConnell, D. J. 1992, ApJS, 82, 471
Surace, C., & Comte, G. 1994, A&A, 281, 653
Surace, C., & Comte, G. 1998, A&AS, 133, 171
Takase, B., & Miyauchi-Isobe, N. 1993, Publ. Natl. Astron. Obs. Japan, 3, 169
Thuan, T. X., Lipovetsky, V. A., Martin, J.-M., & Pustilnik, S. A. 1999, A&AS, 139, 1
Tomita, A., Takeuchi, T. T., Usui, T., & Saitô, M. 1997, AJ, 114, 1758
Ugryumov, A. V., Engels, D., Lipovetsky, V. A., et al. 1999, A&AS, 135, 511
Wasilewski, A. J. 1983, ApJ, 272, 68
Zamorano, J., Gallego, J., Rego, M., Vitores, A. G., & Alonso, O. 1996, ApJS, 105, 343
Zamorano, J., Rego, M., Gallego, J., Vitores, A. G., Gonzalez-Riestra, R., & Rodriguez-Caderot, G. 1994, ApJS, 95, 387
Zwicky, F. 1964a, ApJ, 140, 1467
Zwicky, F. 1964b, ApJ, 143, 192

Table 1. Varimax Rotated Factor Scores Matrix for UVG and ELG Samples

| | $F1$ | $F2$ | $F3$ | $F4$ |
|---|---|---|---|---|
| $SC$ | 0.905 | 0.007 | 0.041 | 0.012 |
| $C$ | 0.530 | −0.097 | 0.111 | 0.052 |
| $UV-ex$ | 0.932 | 0.031 | 0.009 | −0.068 |
| $m_{\rm pg}$ | 0.059 | 0.077 | 0.303 | 0.931 |
| $z$ | −0.121 | 0.037 | −0.695 | 0.642 |
| $M_{\rm pg}$ | 0.156 | 0.037 | 0.870 | 0.324 |
| $T$ | 0.121 | −0.871 | 0.011 | −0.145 |
| $N_{50}$ | −0.124 | −0.187 | 0.575 | −0.019 |
| $Int$ | −0.034 | −0.892 | 0.086 | 0.052 |
| $AGN$ | −0.228 | −0.069 | −0.392 | −0.086 |
| Accumulated Variance (%) | 24 | 41 | 57 | 70 |

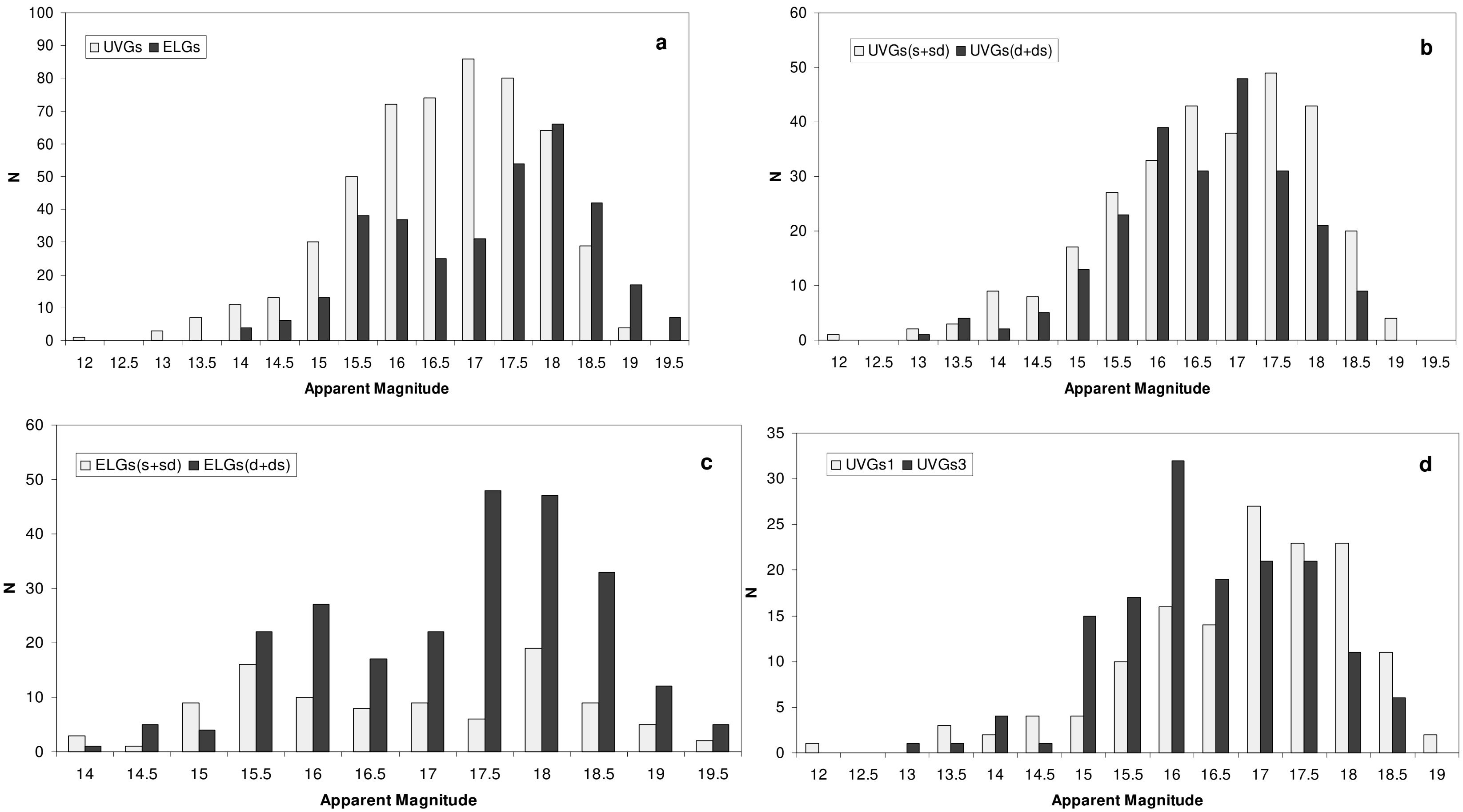


FIG. 1.— Apparent magnitude distributions for (a) SBS galaxies discovered via the UV-excess (UVGs) and the emission line (ELGs) techniques, (b) UVGs with stellar and semi-stellar (UVGs($s + sd$)) and diffuse and semi-diffuse (UVGs($d + ds$)) spectra, (c) ELGs with stellar and semi-stellar (ELGs($s + sd$)) and diffuse and semi-diffuse (ELGs($d + ds$)) spectra and (d) UVGs with strongest (UVG$s1$) and faintest (UVG$s3$) UV-excess radiation.

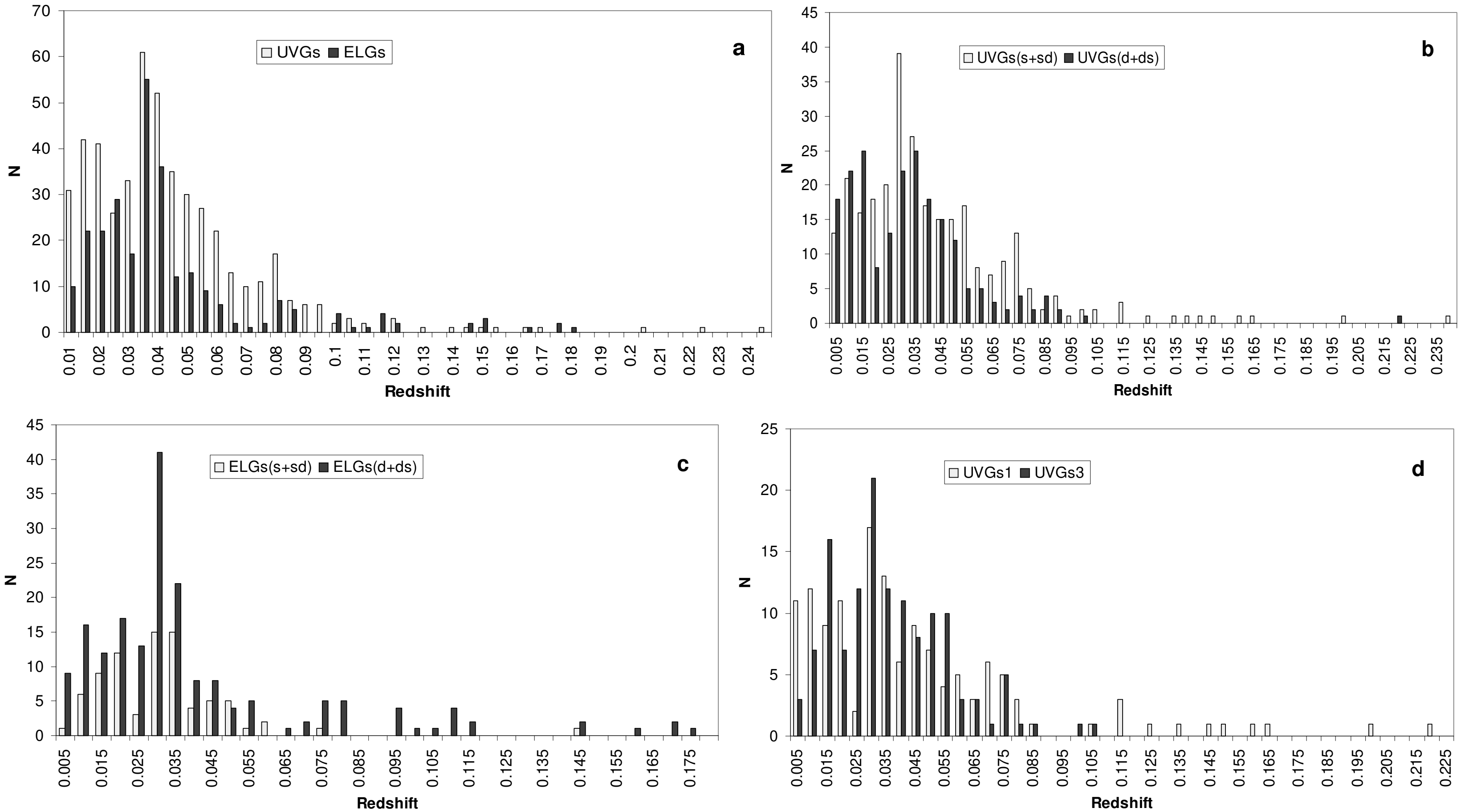


FIG. 2.— Redshift distributions for (a) SBS galaxies discovered via UV-excess (UVGs) and emission lines (ELGs) techniques, (b) UVGs with stellar and semi-stellar (UVGs($s+sd$)) and diffuse and semi-diffuse (UVGs($d+ds$)) spectra, (c) ELGs with stellar and semi-stellar (ELGs($s+sd$)) and diffuse and semi-diffuse (ELGs($d+ds$)) spectra and (d) UVGs with strongest (UVG*s1*) and faintest (UVG*s3*) UV-excess radiation.

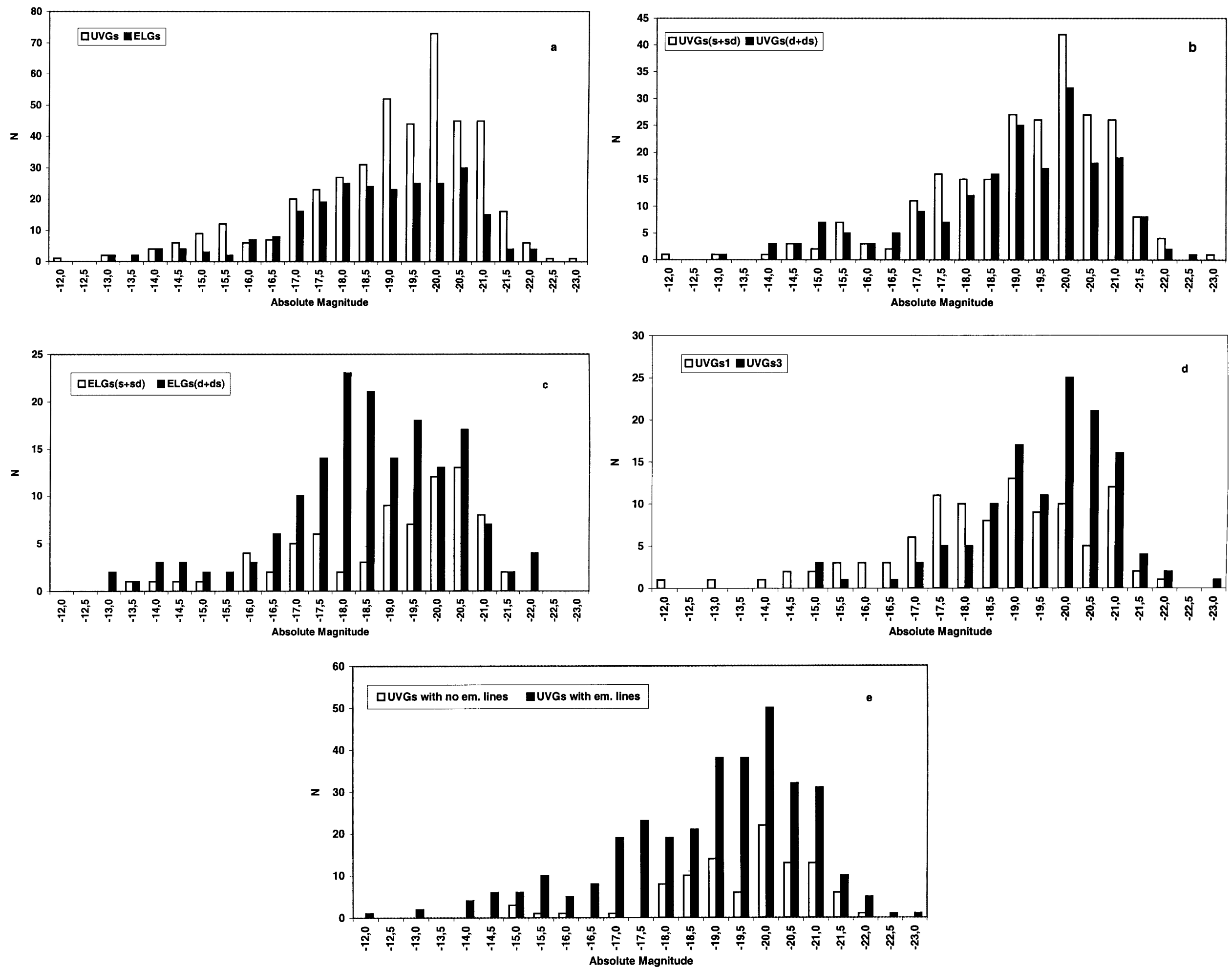


FIG. 3.— Absolute magnitude distributions for (a) star-forming SBS galaxies discovered via UV-excess (UVGs) and emission lines (ELGs) techniques, (b) UVGs with stellar and semi-stellar (UVGs($s+sd$)) and diffuse and semi-diffuse (UVGs($d+ds$)) spectra, (c) ELGs with stellar and semi-stellar (ELGs($s+sd$)) and diffuse and semi-diffuse (ELGs($d+ds$)) spectra, (d) UVGs with strongest (UVG$s1$) and faintest (UVG$s3$) UV-excess radiation and (e) UVGs with detected (UVGs with em. lines) and no detected (UVGs with no em. lines) emission lines in their objective prism spectra.

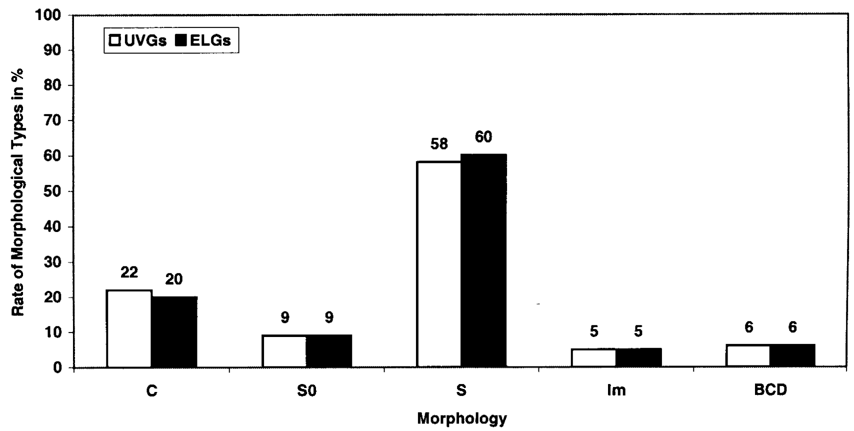


FIG. 4.— Star-forming UVGs and ELGs distributions (in %) as compact, S0, spiral, Im and BCD morphological type objects.

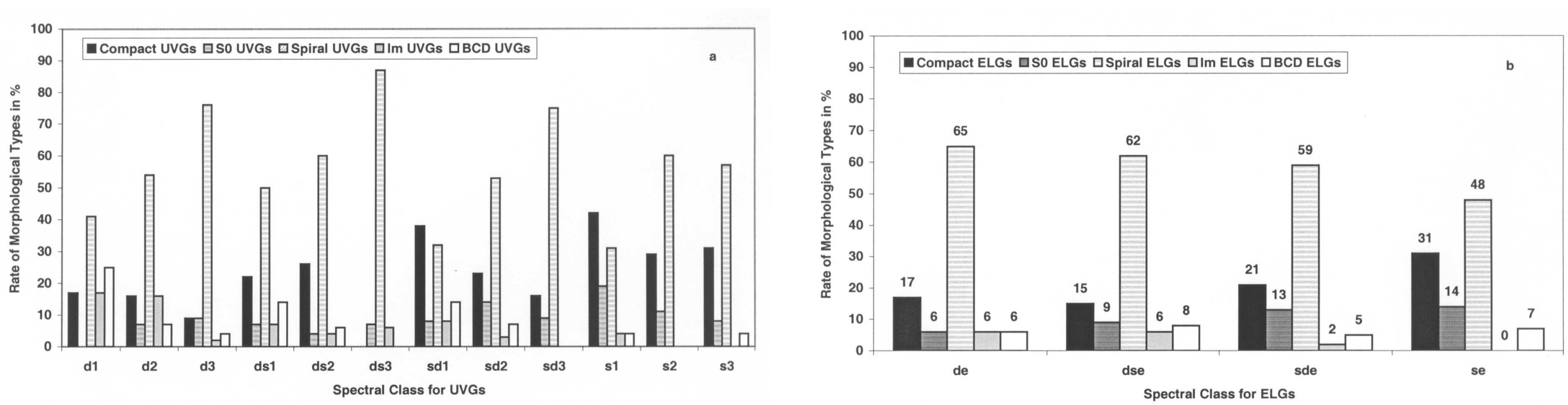


FIG. 5.— Compact, S0, spiral, Im and BCD morphological types distributions (in %) in all spectral classes for (a) UVGs and (b) ELGs.

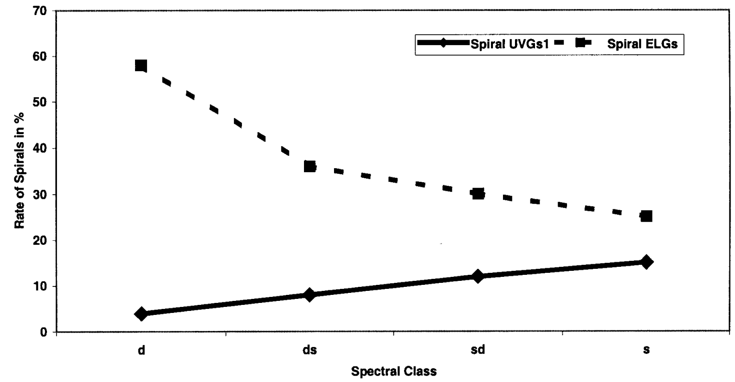


FIG. 6.— The rates (in %) of spiral UVGs with strongest UV-excess radiation and ELGs (spiral ELGs) in *d, ds, sd* and *s* spectral classes.

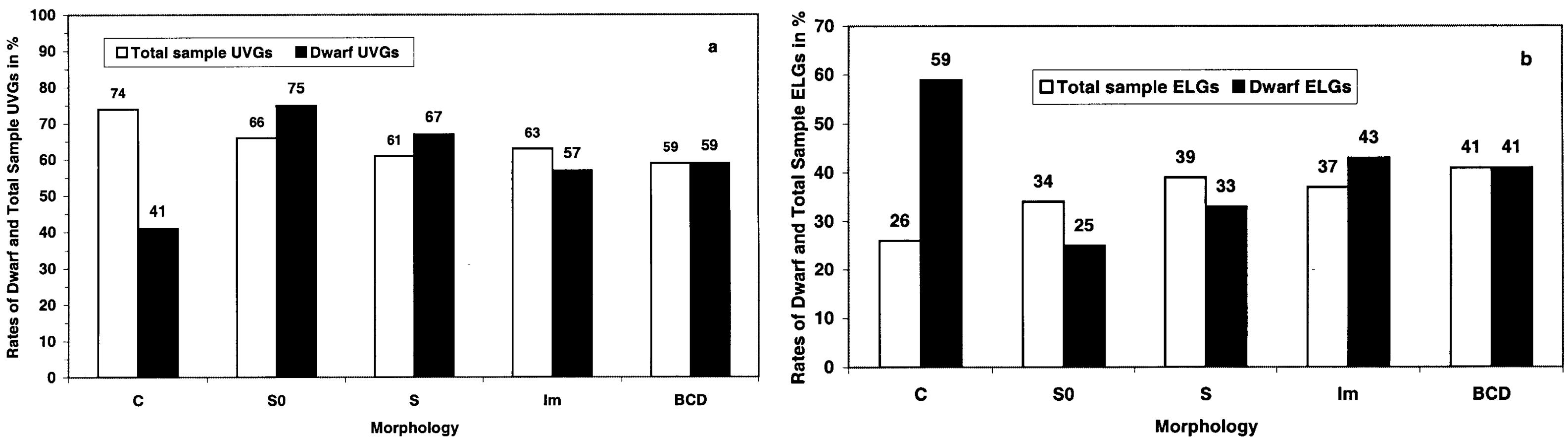


FIG. 7.— The rates (in %) of dwarf ($M \geq -17$) and total sample galaxies with compact, S0, spiral, Im and BCD morphologies for (a) UVGs and (b) ELGs.