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THE MORPHOLOGIES OF DWARF MARKARIAN GALAXIES

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The morphologies of the 96 dwarf ($M(B) \geq -17^m$) galaxies in the Markarian catalog are determined from the digitized Schmidt plates obtained for the construction of the Hubble Space Telescope Guide Star Catalog. The fraction of double nucleus galaxies within the dwarf Markarian galaxies is determined to be twice that found for all galaxies in the Markarian catalog. In addition to the 12 previously known cases, four definite and two probable galaxies with double nuclei are identified. The fraction of dwarf Markarian galaxies with bright star forming regions is found to be twice that of Virgo cluster dwarf galaxies. No Elliptical galaxies are found in the sample. Galaxies with blue compact dwarf and S0 morphologies are more often found to contain unresolved regions of UV excess emission. Dwarf Markarian galaxies with different morphological structure and spectral classes are found to have similar FIR properties.

1. *Introduction*. Understanding the relationship between the morphology of galaxies and their general properties has been one of the most interesting and yet time-consuming objectives of modern astronomical research. Since morphological structure is a fundamental property of a galaxy any sample selected by any other parameter or property should be kept morphologically homogeneous. This paper examines the morphologies and general properties of a sample of dwarf galaxies drawn from the sample of 1500 UV excess galaxies cataloged by the First Byurakan Spectral Sky Survey (FBS; [1,2] and references therein).

The FBS objective prism survey selected galaxies on the basis of their strong ultraviolet continuum radiation. About 10% of the Markarian galaxies have Seyfert nuclei [3] while about 80% have rather uniform spectral properties resembling those of HII regions. These galaxies have been classified variously as starburst galaxies [4,5], HII galaxies [6], and Blue Compact Dwarf galaxies [7] based primarily on their spectral properties and without a systematic investigation of their morphological structures.

Absence of information on the morphological structure of these galaxies has in some cases led to the multiple classifications. More than ten galaxies (e.g. Mrk 140, 206) have been classified as BCDGs [7] and as galaxies with starburst nuclei [5].

The Markarian galaxies have been used by many authors to study general statistical trends and to build up a coherent physical picture of star formation, the AGN phenomenon, and the connection between AGN and star formation. Because morphological misclassifications can confuse such studies, and to obtain a better understanding of the natures of the various types of Markarian galaxies, we are conducting a study of the morphological properties of the Markarian galaxies to form a complete and homogeneous database of their morphological structure. In this paper data on the dwarf Markarian galaxies are presented.

In Section 2 we describe the sample of the dwarf Markarian galaxies. In Section 3 we present data on their morphological structures, FBS spectra, diameters, and IRAS fluxes. In Section 4 we discuss the results and look at correlation among several parameters. Our conclusions are presented in Section 5.

2. *Definition of the Sample of Markarian Dwarf Galaxies.* All galaxies with blue absolute magnitudes $M(B) \geq -17^m$ were selected from the FBS catalog [2] yielding a sample of 96 galaxies (Table 1). Because magnitude estimates by Markarian and colleagues at the fainter apparent magnitudes were based in part on the objective prism plates which only estimate the magnitude of the emission regions [1], about 30% of the galaxies in the dwarf sample have apparent magnitudes that are typically 1 to 1.5 magnitudes fainter than the true total photographic or B-magnitudes of these galaxies (see [8]). Therefore some of the galaxies in our sample may be more luminous than expected; galaxies for which this may be a factor are indicated in Table 1 with an "*". Distances for each galaxy are obtained mostly from the redshifts presented in [2] assuming a uniform Hubble expansion of 75 km s^{-1} Mpc^{-1}. After 1989 for a number of dwarf Markarian galaxies, new, more accurate determinations of redshifts have been done. For these cases newly determined redshifts have been used. For the four galaxies with $V(R) < 500$ km s^{-1} distances are taken from [9]. The galaxies blue luminosities, in solar units (where $M_0(B) = +5.48$), are calculated using the photographic absolute magnitudes presented in [2] with a correction for galactic absorption of $A = 0.2\csc(b^{\circ})$. The transformations from photographic to B magnitudes were performed according to [10].

3. *Results. Morphologies.* To support the operation of the Hubble Space Telescope (HST), Palomar Observatory and the Space Telescope Science Institute jointly undertook the "Quick V" survey of the northern sky using the 1.2m Oschin Telescope at Palomar Mountain during the 1980's. Patterned on the National Geographic Palomar Observatory Sky Survey (POSS-I), this survey was conducted to provide recent epoch observations from which, together with the SERC UK Schmidt J band survey in the southern hemisphere, to construct an all sky astrometric catalog of stars appropriate for the HST guidance system. The HST Guide Star Catalogue (GSC, [11-13]) was derived from this material. The plates were digitized with a PDS-2020G microdensitometer with a pixel size of 25 μm (corresponding to 1.7 arcsec at a plate scale of 67 arcsec mm^{-1}).

From these digitized plates, 15x15 arcmin regions centered on each Markarian galaxy were extracted for this study. Since the northern plate material was originally intended for the measurement of stellar objects between 12 and 19 magnitudes, it is more suitable for the morphological study of Markarian galaxies (which are typically between 14 and 17 magnitude) than the often overexposed images on the POSS. 82 of the 96 galaxies in this study are on the northern plates. Furthermore, the uniformity of the GSC survey plates makes them useful for examining the structural features of galaxies. 14 dwarf Markarian galaxies, with low declinations, are in the plates of the Equatorial Extension of SERC UK Schmidt *J* survey. These galaxies are indicated in Table 1 in bold letters.

Using both digital images and isophotal maps (which display the large dynamic range of the images), we classified the sample of dwarf Markarian galaxies within the modified Hubble sequence (E - S0 - Sa - Sb - Sc - Sd - Sm - Im) and the extension Blue Compact Dwarf (BCD).

While it is relatively simple to classify large scale galaxies in this sequence (for example Mrk 170 as SBc type galaxy), the most difficult types to classify morphologically are the compact galaxies. More than 60 galaxies in our sample have designations as compact or spherical objects in Markarian's original lists ([2] and references therein). We have re-classified each galaxy in our sample according to the criteria listed in Table 2. Mrk 223 and Mrk 1308 respectively are examples of the S0 and BCD type galaxies. Markarian irregular galaxies usually contain at least one giant star forming region that is the main source of the excess UV radiation. Sandage and Binggeli [14] designate giant HII regions in irregular galaxies as BCDs. We have expanded this approach by classifying such galaxies by the composite notation Im/BCD when the underlying Im system dominates and by BCD/Im when the BCD component (oftentimes with several knots) dominates. Mrk 5 and Mrk 192 respectively are examples of Im/BCD and BCD/Im type galaxies. In five cases (Mrk 71, 94, 404, 1039 and 1315) the Markarian "galaxies" are actually giant HII complexes within larger galaxies. These cases are noted in Table 1 as BCD/HII and are excluded from our analysis in Section 4.

In Fig.1, as examples of S0, spiral, Im/BCD, BCD/Im, BCD and BCD/HII objects, images of the Mrk 223, 170, 5, 192, 1308 and 1039 are shown as both halftone images and contour plots. For Mrk 1039 the position of Markarian object in its host galaxy is marked. The field size (and thus magnification) was selected individually for each galaxy to clearly illustrate their individual morphological structures. In the same fashion, the contour levels vary from galaxy to galaxy to better show the inner as well as outer structure of each galaxy. In all cases, the lowest contour level corresponds roughly to a surface brightness of about 25 mag arcsec^{-2} (see below).

FBS Spectral Classifications. Markarian [1] assigned a spectral classification for each UV excess galaxy that describes the degree of condensation of the UV emission and its relative intensity. This scheme classifies the UV emitting regions as stellar (s) type or diffuse (d) type where the halfwidth of emission regions are of the order of 2 or 6-8 arcsec, respectively. The intermediate types (sd) and (ds) are also used. A number between 1 and 3 is used to indicate the

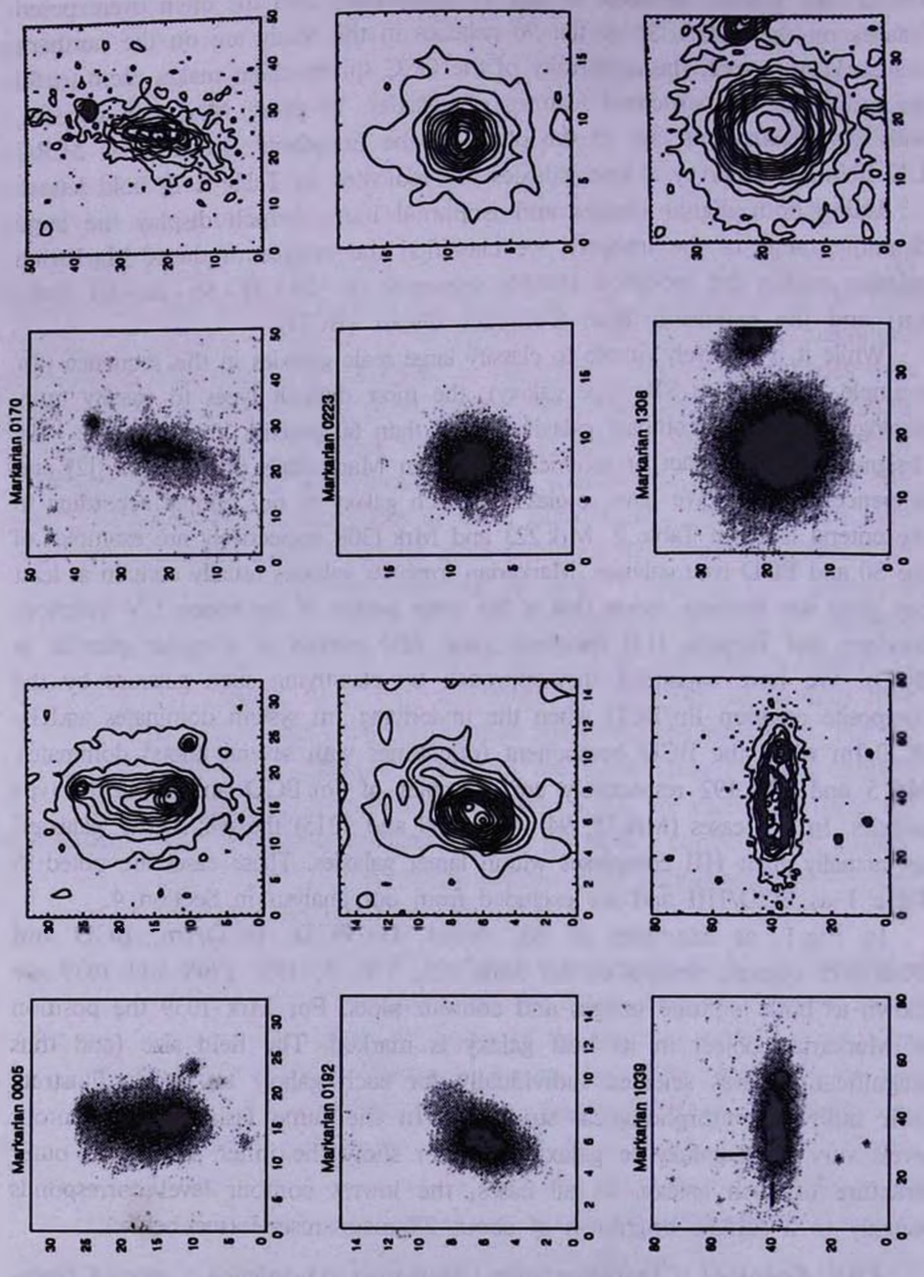

Fig.1. As example of S0, spiral, Im/BCD, BCD/Im, BCD and BCD/HII objects gray-scale representations and contour plots of *V* images of Mrk 223, 170, 5, 192, 1308 and 1039 are presented. The positiion of Mrk 1039 in its host galaxy is marked. North is up and east is to the left. The axes units are in pixels on the digitized plates where 1 pixel corresponds to 1.7 arcsec. The contour levels were selected to "best" reveal the structure of each galaxy.

relative intensity of the UV emission with 1 being the greatest UV excess.

Diameters and Magnitudes. The major diameters of dwarf Markarian galaxies were measured from the faintest isophote in each of our images. To estimate the surface brightness of these isophotes, we compared our measured *V*-band linear diameters and the [7] 25 *B* mag arcsec^{-2} linear diameters for the 41 dwarf galaxies common to both samples. The [7] linear diameters were recalculated using the redshifts of [2]. The relation between the [7] diameters and our diameters is well correlated ($r = 0.91$) and is shown in Fig.2. The slope of linear interpolation of the relation is equal to 0.94 ± 0.07. Because the galaxies

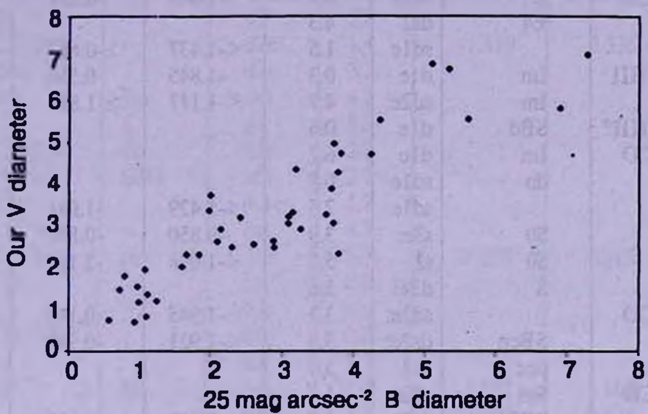

Fig.2. Comparison between our *V* linear diameters (in kpc) and [7] 25 mag arcsec^{-2} in *B*-band diameters (in kpc).

in common are mostly BCDs no morphological segregation was done. Since diameters of the galaxies in *B* and *V* colors usually are equal (e.g. [15,16]), then on average our *V* isophotal diameters are about 25 mag arcsec^{-2} or slightly less.

IRAS Source Identifications and Fluxes. From the IRAS Faint Source Catalog Version 2.0 (FSC2; see [17]) and the digitized optical images, far infrared FSC2 sources were matched with the galaxies in our sample. All IRAS sources within 2 arcmin of each Markarian galaxy were carefully examined by plotting the positions of the FSC2 source(s) on the 15 x 15 arcmin images. If the positions agreed to within 30 arcsec and no confusing optical or IRAS sources were present then a definite identification was made. In this fashion we identified 37 of the dwarf galaxies in our sample with sources in the FSC2. All identified objects are included also in a multifrequency radio continuum and IRAS faint source survey of Markarian galaxies [18]. In Table 1 the $\alpha(25,60)$ and $\alpha(60,100)$ spectral indexes (columns 6 and 7), and logarithmic FIR to *B* luminosity ratios (column 8) are reported. The FIR flux has been computed according to [19] and reflects the output over the 40 to 120 μm region. The *B* magnitudes are as defined in Section II.

Table 1

MARKARIAN DWARF GALAXIES

Mrk	Morph	Old Morph	Sp	*D*(kpc)	α(25,60)	α(60,100)	logFIR/B
1	2	3	4	5	6	7	8
5	Im/BCD	Im	d1e	2.6	<-1.568	-2.738	-0.49
22	BCD/Im		d1e	3.7			
27	BCD	pec	d1	2.6			
32	Im/BCD	pec	d2	1.2			
36	Im/BCD	Im	d1e	1.8	<-0.777	-2.167	-0.29
46	S0		d3	6.9			
49	Im/BCD	E	ds1e	6.9	<-1.649	-0.251	-0.54
51	S0	E4	ds2	4.3			
67	BCD		sd1e	1.5	<-1.437	≥-0.613	<-0.07
71	BCD/HII	Im	d1e	0.3	-1.845	-0.556	-1.10
89	S0	Im	sd2e:	4.7	<-1.117	≥-1.826	<-0.62
94	BCD/HII?	SBd	d1e	0.6			
108	Im/BCD	Im	d1e	6.7			
116	BCD	db	sd1e	0.8			
140	S0/a		sd1e	2.5	<-1.429	-1.041	-0.59
149	S0	S0	s3e:	3.9	-0.850	-0.841	-0.80
151	S0	S0	s2	5.5	<-1.098	-2.195	-0.71
164*	Sb	S	d3e:	5.6			
169	Im/BCD		sd2e:	3.3	-1.945	-0.180	0.23
170	SBc	SBcp	ds2e:	5.8	<-1.921	-0.932	-0.65
177	BCD	pec	ds2	3.0			
178	Im/BCD	Sm	sd2e	1.2			
186	SB0/a	SB0/a	ds1e	2.3	-2.302	-1.630	-0.78
192*	BCD/Im		s3e:	5.2			
206	BCD		s1e:	3.2	-1.920	-0.631	0.07
209	Im/BCD	Sm?	d1e	0.7			
223	S0		s1e:	2.0	-2.161	-0.837	-0.19
224	Im/BCD	Im	d3	2.9			
234	Sb	S0/a	d3e:	5.5			
263*	S0		sd1e	2.5	<-1.334	-2.057	-0.15
277	Im/BCD	Im	d1e:	6.7	<-1.460	-1.917	-0.44
324	BCD		d2	2.3			
328	SB0	SBbpec	ds1e	3.2			
404	BCD/HII	SABbc	d2	0.8	-2.485	-1.352	1.13
407	S0		sd3e:	3.3			
408	S0		ds2e:	4.3	≤-1.930	-1.708	-0.61
411	S0		d3	4.7	≤-0.265	-1.138	-0.75
416	S0	S0	sd2e:	7.1	≤-1.399	-0.936	-0.33
426	Sc	Sc	d3	5.0			
429	S0		ds2e:	2.9			
450	Im/BCD	Im	d1e	3.1	≤-1.501	-1.076	-0.49
475*	BCD		ds2e	0.7			
487	BCD		d2e	1.3	≤-1.317	-1.462	-0.59
600	Im/BCD	SBb	d2e	3.3			
641*	BCD		sd2e:	2.5			
675*	S0		d2	5.3			
714	BCD		ds3	1.9			
724*	BCD		sd1e	1.9			
746	Sb	Im	d2	4.1			
747	S0/a		d2e:	2.3			
750	BCD/Im		ds2e	1.4	≤-0.936	-1.263	-0.30

Table 1 (continued)

1	2	3	4	5	6	7	8
756	BCD		s2e	4.1	≤-0.758	-1.851	-0.41
757	BCD		d3	1.5			
772	BCD/Im	E0	s3	3.8			
773	Im/BCD	S	d3e:	2.6	≤-1.961	0.299	-0.80
786	BCD/Im		ds2e	3.5	≤-1.416	-1.289	-0.60
826*	Im/BCD		ds3	1.8			
850*	BCD		s2	2.3			
900	BCD/Im	E	d2	4.2	≤-1.020	-2.352	-0.57
931*	S0		d3e	10.7			
996*	BCD		ds2e	5.6	≤-1.050	≥-1.045	≤-0.24
1025*	SBb		d2	5.8			
1039*	BCD/HII		d2e	1.4	-1.819	-0.536	0.27
1042*	Sbpec		d3e	3.3			
1131*	SBab	Im	ds3	4.2			
1153	Sc	S	d3	8.9			
1263*	BCD/Im	db	d1e	2.8			
1264	S0/a	S0/a	sd3	2.7			
1271	BCD		ds1e	1.7			
1306*	BCD/Im		ds1	4.7			
1307	BCD/Im	pec	d1e	3.3	-2.257	0.102	-0.57
1308	BCD		s1e	4.0			
1313*	S0		ds2	4.2			
1315	BCD/HII?		d1e	0.6			
1323	SBa		d3	3.3			
1333*	SBb	S?	ds3e:	19.2	≤-1.752	-1.163	0.25
1335	S0		sd2e:	2.4	≤-0.607	-0.424	-0.49
1338	S0pec		d3	3.9			
1342*	SB0		d3e:	10.5	≤-1.060	-1.386	-0.41
1369*	S0pec		ds1e	5.0	≤-1.315	-0.792	0.36
1384*	BCD		sd1e:	2.5			
1390	SBb	S?	d3	3.8			
1416*	BCD		d1e	3.9			
1418	Im/BCD	pec	sd2e:	2.8	≤-1.837	-1.328	-0.98
1423	S0	S	sd2e	4.8			
1426*	BCD		d3e:	2.0			
1427	S0		d3	5.6			
1434*	BCD		ds1e	2.0			
1445*	Sab		ds2e	4.6			
1446*	BCD		sd2e	5.0			
1450	BCD		sd1e	1.0	≤-1.161	-1.415	-0.47
1460*	BCD		d2e:	0.9			
1479	SBdm	SABdm	ds2e	1.0			
1480*	BCD		sd1e	2.5			
1481*	BCD		d1e	2.2			
1499	BCD		ds1e	4.7	≤-1.962	-1.721	-0.12

Notes to Table 1

The columns contain (1) the Markarian number. "*" marks galaxies which may be more luminous than expected, (2) the morphological type in the present classification scheme (see text for the meanings of the designations), (3) the morphological classification according to [2], (4) the spectral classification from [2], (5) the linear diameter in kiloparsecs at about 25 V magnitudes arcsec^{-2} diameter, (6) the $\alpha(25,60) = -\log(f_{25}/f_{60})/\log(25/60)$ spectral index, (7) the $\alpha(60,100) = -\log(f_{60}/f_{100})/\log(60/100)$ spectral index, and (8) the ratio of FIR to blue luminosity. Alternate names and additional information on the morphological structure for some individual galaxiies are given in the Appendix.

4. *Discussion*. *Morphologies*. [2] provide morphological information for 42 of the 96 dwarf galaxies in our sample. Our study confirms the nature of 7 of these and provides a more accurate classification of 19 others. However, in 16 cases our classifications differ. Of these 56% had been assigned earlier and 25% later morphological classifications than obtained in the present study. In three cases (Mrk 71, 94 and 404) the Markarian object is actually an HII region in a large galaxy. For those galaxies [2] presented the morphological class of the parent galaxy. For the 23 dwarf galaxies in our sample classified as Compact in [8], we provide more accurate classifications.

On the basis of higher resolution images than the POSS, 12 galaxies in our sample previously had been defined as "double nucleus" galaxies on (Mrk 22, 116, 186, 324, 487, 600, 786, 900, 1263, 1307, 1426 and 1479). We find evidence that four additional objects (Mrk 192, 996, 1323 and 1342) have "double nucleus" structure and suspect that two others (Mrk 1025 and 1306) also have "double nucleus" structure. In eight cases the galaxies with "double nucleus" structures have Im/BCD or BCD/Im morphologies, in five cases BCD morphologies, in four cases spiral and in one case S0 morphologies.

A reasonable interpretation of the "nuclei" in the Irregular and BCD galaxies may be that they are actually giant HII regions. Their real nuclear nature in spiral galaxies remains to be confirmed.

The fraction of "double nucleus" galaxies in our sample (19%) is twice that expected for the entire sample of Markarian galaxies [20]. Most (89%) of the dwarf Markarian galaxies with "double nucleus" structures are found among the galaxies with diffuse spectra (d) and (ds).

Table 2

CLASSIFICATION CRITERIA

E	S0	BCD
The concentration of the brightness must be situated symmetrically about the galaxy center.	The concentration of the brightness must be situated approximately symmetrically about the galaxy center.	The concentration of the brightness can be shifted from the center of symmetry of the whole galaxy.
All isophotes of the galaxy must be symmetrical and well shaped.	Only inner isophotes of the galaxy must be approximately symmetrical.	Inner as well as outer isophotes are assymmetrical and disturbed.
Radial intensity distribution in one component.	There is evidence of a two component bulge-disk disk structure from the radial intensity distribution.	There is evidence of a one component structure from the radial intensity distribution which gradient and peak surface brightness is lower than in the case of the dwarfs classification as S0s. Usually two or more brigtness concentrations are present.

The morphological type distribution for the dwarf Markarian galaxies with other parameters is shown in Table 3. No Elliptical galaxies (as defined in Table 2) are found in our sample. In a sample of 87 Markarian galaxies (excluding Mrk 171, 271, 430 and 496 since they are closely interacting or disturbed systems), [3] found 15% of the galaxies to be Ellipticals (with 10% S0, 62% Spiral, and 13% Irregular galaxies). However, [21] finds that the Markarian galaxies classified as Elliptical by [3] are not normal Elliptical galaxies and that the fraction of normal Ellipticals among the Markarian galaxies is less than 1%. Our data are in good agreement with this conclusion. The high fraction of Irregular as well as BCD galaxies among dwarfs, compared with the total sample of Markarian galaxies, is mainly a luminosity effect.

The distribution of morphologies in the sample of 92 Virgo cluster dwarfs of [14] is given in Table 3. The selection of the dwarf Markarian sample on the basis of strong UV excess radiation (which directly relates to current high star formation rates) accounts for the reduced fraction of early type galaxies and the enlarged fraction of the late type galaxies with bright star forming centers (giant HII regions) or BCDs in the Markarian sample.

There is a higher fraction of S0 galaxies in our sample than in the Sandage and Binggeli [14] sample of Virgo cluster dwarfs. A central stellar nucleus is observed in the direct images of some of these (e.g. Mrk 263, 407). These objects may be similar to RMB56 [22] with an exponential disk resembling a compact Sm or Im galaxy seen face-on and a compact HII region at its center. Or they may resemble Haro 2 [23] with a nuclear star forming region superimposed on a low surface brightness (i.e. low star formation rate) elliptical component. In either case these S0 galaxies share a number of

Table 3

SEVERAL PARAMETERS FOR DWARF MARKARIAN GALAXIES

Morphology	Percentage of sample (present paper)	Percentage of Virgo dwarfs [14]	z	M_B	D(kpc)	(s+sd):(ds+d)
dE	-	34%	-	-	-	-
S0	22%	-	0.0060± .0027	-16.25± .33	4.86±2.31	0.38:0.62
dS0	-	9	-	-	-	-
Spiral	20	8	0.0056± .0025	-16.27± .25	5.03±3.86	0.16:0.84
Im	-	30	-	-	-	-
Im/BCD and BCD/Im	25	-	0.0038± .0022	-15.80± .41	3.34±1.73	0.21:0.79
Im/BCD	-	6	-	-	-	-
BCD	28	13	0.0081± .0016	-15.62± .41	2.51±1.30	0.44:0.56
BCD/HII	5	-	-	-	-	-

characteristics with the BCDs.

It is well known that the fraction of spiral galaxies drops sharply among galaxies less luminous than $M(B) = -17^m$ (e.g. [24]). The rate of spiral galaxies in the sample of dwarf Markarians is 20%. If we will not account spiral galaxies with possibly higher luminosities that dwarfs sample selection limit (spirals marked with "*" in the Table 1), the rate of spiral galaxies will become 12%. It is close to the rate of spiral galaxies in the Virgo dwarf galaxies sample [14].

FBS Spectral Type. In the galaxies where the UV excess radiation is related to the enhanced star formation, the extent of the UV emitting region indicates whether the enhanced star formation occurs in an isolated region or extends over a large portion of the galaxy. We note that selection effects introduced by the large range of redshifts and hence linear sizes must be taken in account. In Table 3 the fractions of stellar (s + sd) and diffuse (d + ds) spectral class objects for each morphologcal type of dwarf Markarian galaxy are presented. To control for selection effects, the average blue absolute magnitudes, redshifts and linear diameters are also reported. Since BCDs have significantly higher redshifts, smaller liniar sizes and lower luminosiities that dwarfs of other morphological types, higher fraction of compact UV excess regions in them partially can be due by selection effects. Higher fraction of compact UV excess regions in S0 galaxies result from concentration of star formation activity in the nuclear region of these objects. The enhanced number of compact UV excess regions in the S0 and BCD galaxies suggest the similarity between of some of the galaxies of these two types. In both the spiral and irregular galaxies these are often a diffuse component associated with extended star formation. In all 5 objects with HII/BCD classification diffuse radiation of UV excess is dominated.

IRAS Galaxies. Thirty-seven of the dwarf Markarian galaxies in our sample are included in the IRAS FSC2. Giant HII regions within much larger galaxies (Mrk 71, 404 and 1039) are also included in the FSC2. In these cases, the Far Infrared (FIR) flux comes from both the HII region and the underlying galaxy. Therefore these three objects have been excluded from the discussion of the FIR properties of our sample. The 37% fraction of FSC2 sources in our sample is about 1.5 times less that is found by [18] for the entire sample of Markarian galaxies and about twice less that is found for Markarian galaxies with thermal emission-like spectrum [25]. Low FIR detection rate of dwarf Markarian galaxies can be reflection of the tendency discovered for the low luminosity galaxies in general [e.g.26].

Table 4 presents the percentages of FIR detected galaxies among different morphological types of dwarfs. In the same Table for the same morphological types the distribution of FIR detected galaxies according to their FBS spectral types as well their average FIR spectral indexes and FIR to blue luminosity ratios are presented. Among dwarf Markarian galaxies FIR detection rate

Table 4

FIR PARAMETERS FOR DWARF MARKARIAN GALAXIES

Morphology	Percantage	(s+sd)/(ds+d)	α(25,60)	α(60,100)	logFIR/B
S0	48%	6/4	-1.20±0.57	-1.20±0.52	-0.40±0.35
Spiral	26%	2/3	-1.70±0.46	-1.39±0.52	-0.50±0.42
Im/BCD and BCD/Im	50%	2/10	-1.53±0.45	-1.18±1.00	-0.49±0.30
BCD	26%	4/3	-1.37±0.44	-1.25±0.50	-0.26±0.24

approximately is twice less for Spiral and BCD galaxies than for S0 and Im dwarfs. Among FIR source Im dwarfs the content of the objects with diffuse UV radiation (d + ds type) is significantly higher than objects with stellar UV spectra (s + sd type). No significant differences between FIR properties of the dwarfs of different morphological types are found.

For IRAS detected and non-detected dwarf galaxies the distributions of the redshifts and *B* magnitudes were analyzed. The non-parametric two sample K - S test on these distributions shows that the IRAS sources are closer ($<z> = 0.0041$) than non-detected galaxies ($<z> = 0.0053$) at the 94% significance level. This implies that this selection effect rather than the intrinsic properties of the galaxies has reduced the fraction of IRAS detected objects in the sample of dwarf Markarian galaxies.

Multivariate Factor Analysis. The Multivariate Factor Analysis (MFA) method may be applied to a more general investigation of the properties of our sample of dwarf Markarian galaxies. MFA is a statistical method of locating correlations among of set of initial variables measured for each of a set of objects. MFA derives a reduced number (i.e. less than the number of initial variables) of linearly independent factors that explain the correlations. A detailed description of the MFA method can be found in [27] and [28] and several applications of this technique to astronomical problems have previously been published (e.g. [29-31]). To express the initial variables in terms of the smaller number of common factors the Varimax orthogonal rotation [32] was applied to the factor.

For the analysis of our sample the three FIR parameters (log(L(FIR)/L(B)), α(25,60) and α(60,100), the linear diameters of the galaxies, and two variables, *M* and *S*, representing the morphological type and spectral class respectively were used as initial variables. Because of limited sensitivity of the IRAS survey at 25 μm, some of the α(25,60) spectral indices are upper limits (see Table 1). The following analysis was performed accounting for the upper limits, but it was verified that similar conclusions are reached when α(25,60) is excluded as an initial variable.

In the Table 5 the factor loadings (i.e. the correlation coefficients between the initial variables and the factors), and the accumulated variance for the three Varimax rotated factors are presented. In total 69% of the common

Table 5

VARIMAX ROTATED FACTOR MATRIX

	RF1	RF2	RF3
Morphology (*M*)	0.672	-0.181	-0.542
Spectral type (*S*)	0.678	0.191	-0.120
D(kpc)	-0.001	0.037	0.923
α(25,60)	-0.313	0.740	0.022
α(60,100)	-0.215	-0.818	-0.066
logFIR/B	0.659	-0.279	0.284
Accumulated Variance (%)	25	23	21

variance is accounted for when a value of $r=0.7$ is adopted as the correlation threshold. The first rotated factor, RF1, which accounts for 25% of the common variance, does not combine any parameter. The second factor, RF2, which describes 23% of the total variance, combines α(25,60) and α(60,100) FIR spectral indexes. The third factor, RF3, (21%) is dominated by the linear size of the dwarf Markarian galaxies.

The MFA has shown that the strongest correlation among the 6 initial variables is found with the FIR parameters. Because of the close correlation between FIR properties and current star forming activity in galaxies [33-35], the RF2 factor may be interpreted as a star formation activity factor for dwarf Markarian galaxies.

In the MFA, the individual factors, and hence their corresponding sets of initial variables, are independent. Therefore, for the dwarf Markarian galaxies, star formation activity is not related to a galaxy's morphology, spectral class, or linear size.

5. *Conclusions*. From the STScI digitized Schmidt plates of the sky used in the construction of the HST Guide Star Catalogue, we have studied the morphologies of the 96 dwarf ($M \geq -17^m$) Markarian galaxies. Their morphological types, linear diameters, FIR parameters (for the 37 sources present in the IRAS FSC2), and Markarian spectral classes are used in this study. The main results are summarized below.

1. Morphological classifications for 54 of the 96 dwarf galaxies in the Markarian catalog are made for the first time. The previous morphological classifications of 7 galaxies are confirmed, more accurate classifications are obtained for 19 galaxies, and earlier classifications are corrected for the remaining 16 galaxies.

2. Besides the 12 galaxies previously known to have "double nucleus" structure in this sample, 4 additional "double nucleus" galaxies and 2 more candidates are found. Therefore the frequency of "double nucleus" dwarf Markarian galaxies is twice that of all Markarian galaxies.

3. None of the dwarf Markarian galaxies are Elliptical galaxies.

4. The fraction of the galaxies that contain at least one bright star forming region (Im/BCD, BCD/Im or BCD type galaxies) in our sample

is 2.5 time higher that found in [14] sample of Virgo cluster dwarf galaxies.

5. Compared with spiral and irregular galaxies, the S0 and BCD galaxies more often contain unresolved UV excess emitting regions than diffuse regions. This argues for a considerable similarity between the S0 and BCD galaxies.

6. Multi-factor analysis shows that dwarf Markarian galaxies with different morphological structures, spectral classes, and sizes have similar FIR properties.

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МОРФОЛОГИЯ КАРЛИКОВЫХ ГАЛАКТИК МАРКАРЯНА

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Используя оцифрованные Шмидтовские пластинки, которые получены для создания Каталога Звезд Гидирования для Хаббловского телескопа определены морфологии 96 карликовых ($M(B) \geq -17^m$) галактик Маркаряна. Доля двухядерных объектов среди карликовых Маркаряновских галактик двое больше, чем в общем каталоге Маркаряновских галактик. Уже известным 12 галактикам прибавлены 4 определенные и 2 возможные новые двухъядерные галактики. Доля карликовых Маркаряновских галактик с яркими областями звездообразования вдвое больше по сравнению с карликами в скоплении Девы. В выборке эллиптических галактик не обнаружено. Галактики морфологически классифицированные как Голубые Компактные Карлики и S0 галактики намного чаще имеют неразрешенные области избытка УФ эмиссии. Карликовые Маркаряновские галактики с разной морфологической структурой и разными спектральными классами имеют одинаковые свойства в далекой ИК-области.

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Appendix

Mrk 5 (KUG0635+756) is an Im galaxy with BCD properties [36, 37].

Mrk 22 (KUG0946+558) is an interacting pair [38]. It has also been classified as an Im type galaxy with two giant star forming regions in its central region [36,39].

Mrk 27 (KUG1008+589) has a spherical central structure with irregular short extensions [36].

Mrk 32 is an Im galaxy with at least three star forming regions.

Mrk 36 (Haro 4, KUG1102+294).

Mrk 46 (KUG1213+412).

Mrk 49 = Mrk 1318 (UGC7354, Haro 8) is a BCD - giant HII region in the north end of the galaxy [14].

Mrk 51 is a dS0 type galaxy [40].

Mrk 67 (KUG1339+307) has its nucleus slightly displaced towards the southeast with respect to the center of the outer isophotes [36].

Mrk 71 (NGC2363) is a giant HII region within the IBmIV-V dwarf galaxy NGC2366. This is a composite system with at least 3 HII complexes [41].

Mrk 94 is superposed on the SBd type spiral galaxy UGC4499. It can be classified as either a giant HII region in UGC4499 [42] or as an isolated BCD.

Mrk 108 (NGC2820A, IC2458, VIIZw276) is a close companion of NGC2820. It has been classified as an I0pec type galaxy by [43] and as Im? by [3].

Mrk 116 (IZw18, KUG0930+554) has two or three additional condensations which are seen in higher resolution images [44,45].

Mrk 140 (KUG1013+455) has a faint spiral structure [39].

Mrk 149 (UGC5776, VIIZw339).

Mrk 169 (IC691, UGC6447).

Mrk 170 (UGC6448) is type SBc and has 4 giant HII regions [46].

Mrk 177 (KUG1130+553).

Mrk 178 (UGC6541) is a BCD with two bright HII regions near its center surrounded by a patchy nebulosity [47].

Mrk 186 (NGC3870, UGC6742) is SBc with three giant HII regions in its equatorial plane [20].

Mrk 192 contains at least three condensations. Two of these have similar brightness' and are very close to one another.

Mrk 209 (Haro 29, IZw36) is an iE type BCDG [48].

Mrk 223 (VIIZw483).

Mrk 263 (KUG1331+691).

Mrk 277 (VIIZw528) is an Im galaxy with four HII regions in a common envelope [49].

Mrk 324 is a close double system which is merged in a compact spherical envelope [36,39,50].

Mrk 328 the galaxy has been classified as E3 by [3]. The nucleus lies on the major axis but is offset 1 arcsec from the isophotal center [36].

Mrk 404 (KUG0939+320) is a HII region in NGC2964.

Mrk 407 (KUG0944+393).

Mrk 411 (IC2524, KUG0954+338, IZw524).

Mrk 416 (UGC5833).

Mrk 426 (KUG1138+354).

Mrk 429 (KUG1143+351) has a spherical bulge within a faint envelope [38].

Mrk 450 (UGC8323, VV616, KUG1312+351) is a "nest" of at least three giant HII regions in the classification of [51].

Mrk 487 (IZw123) has two central condensations in a low luminosity, extended, regular envelope [52].

Mrk 600 has a double nucleus [20,53] (see also [39])and is a SBc type galaxy with a giant HII region in its southern arm. This galaxy has also been classified as an Irr [54] and as an iE type BCDG [48].

Mrk 641 (KUG1149+351).

Mrk 675 (KUG1417+365).

Mrk 746 (KUG1138+326, Was27) has a peculiar nucleus [55].

Mrk 747 (UGC6655, KUG1139+162A, Akn311).

Mrk 750 (KUG1147+153).

Mrk 757 (KUG1202+311).

Mrk 772 (Akn375) was classified as a BCD by [40].

Mrk 773 (NGC4509, UGC7704, KUG1230+323) is classified as an iE type BCDG in the [48] scheme [56].

Mrk 786 (NGC5058, UGC8345) contains two diffuse condensations [20].

Mrk 826 (KUG1448+526).

Mrk 900 (NGC7077, UGC11755, Akn549) is a double nucleus SBa type galaxy surrounded by a dense envelope [57].

Mrk 931 (NGC7694).

Mrk 996 is a double nucleus galaxy.

Mrk 1025 (KUG0207-090) may have a double nucleus structure.

Mrk 1039 (KUG0225-103) has been classified as an Sc type galaxy [58] and as an Im galaxy with two giant HII regions [39]. In [59] identify the UV excess object with the condensation located at the east end of the galaxy.

Mrk 1042 (KUG0225-104).

Mrk 1153 (UGC931).

Mrk 1263 is an Im galaxy with two giant HII regions [39,60].

Mrk 1264 (UGC5923).

Mrk 1271 (Akn268, Tol1053+064).

Mrk 1306 may contain three condensations in its central region.

Mrk 1307 (UGC6850, UM462) has two distinct emission regions in a common envelope [61,62].

Mrk 1308 (IC745, UGC6877, UM465, Akn332) is a dwarf elliptical with an unresolved nucleus [62].

Mrk 1313 (UM483).

Mrk 1315 is either an HII region in the SBdm spiral galaxy NGC4204 or a BCD galaxy.

Mrk 1323 was classified as Sa? [40]. It has a double nucleus structure.

Mrk 1333 (NGC4628).

Mrk 1335 (KUG1244+268) is an E/S0 type galaxy [63].

Mrk 1338 (KUG1250+255) is a conspicuous spiral galaxy [64].

Mrk 1342 is a spiral galaxy with double nucleus structure.

Mrk 1416 (KUG0917+527) is an Im galaxy with a giant HII region towards the South [38].

Mrk 1418 (UGC5151, KUG0937+485, AKN209) is an Im type galaxy with four HII regions situated within an elongated lenticular envelope [57].

Mrk 1423 (UGC5179).

Mrk 1426 (KUG0946+487) is a double nucleus galaxy [65].

Mrk 1427 (KUG0951+420).

Mrk 1434 (KUG1030+583).

Mrk 1479 (NGC5238, UGC8565, VV828, IZw64) is a SABdm type double nucleus galaxy [57].

Mrk 1499 (IZw159).