

MORPHOLOGY OF LOCAL GALAXIES FROM SDSS

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ABSTRACT

We prepare a catalog of the morphological types of 5840 galaxies within $z = 0.01$. We determine the morphological types by visual inspection using color images from the Sloan Digital Sky Survey (SDSS) DR7. The majority of the sample galaxies are SDSS spectroscopic target galaxies, but we add ~ 900 galaxies whose redshifts are available in the NASA Extra Galactic Database (NED). The fraction of elliptical and lenticular galaxies is ~ 0.06 while spiral galaxies comprise $\sim 30\%$ of the sample with a bar fraction of ~ 0.6 . About half of sample are dwarf galaxies of which $\sim 35\%$ are dwarf elliptical-like galaxies. There is a strong correlation between the morphological types and luminosities of the galaxies, i.e., high luminosities in the early type galaxies and low luminosity in the late type galaxies. The mean luminosity of dwarf elliptical-like galaxies is similar to that of irregular galaxies.

Key words: galaxies: morphology

1. INTRODUCTION

Galaxies in the local universe ($z < 0.01$) are best suited for a detailed analysis of galaxy morphologies, especially for dwarf galaxies, due to their proximity. Understanding dwarf galaxies is of great importance because dwarf galaxies are the most dominant population of the local universe and they are thought to be the building blocks of large galaxies in the CDM cosmology. Most dwarf galaxies are satellite galaxies but some exist as orphan galaxies.

Morphological classification using color images has the advantage of providing information about the stellar populations as well as the structural properties, which makes the resulting morphological types better representative of integral properties of the galaxies than the conventional ones (de Vaucouleurs, 1959; Sandage, 1961). Detection of blue elliptical galaxies from SDSS color images (Strateva et al., 2001) is a good example of the usefulness of color images in galaxy morphological classification. In light of this, we performed morphological classification of nearby galaxies ($z < 0.01$) using the color images of the SDSS DR7 to make a catalog containing a representative sample of visually classified morphological types for local galaxies. A detailed description of the catalog is given in Ann et al. (2015), while this paper summarizes the basic statistics of the morphologies of local galaxies.

2. MORPHOLOGY CLASSIFICATION

The basic observational data for this study are the color images of the SDSS DR7. We select the majority of the galaxy sample from the Korea Institute for Advanced Study Value-Added Galaxy Catalog (Choi et al., 2010). We add ~ 900 galaxies from NED to make a total sample of 5840 galaxies with redshifts less than $z = 0.01$.

We adopt the classification scheme of the Third Reference Catalog of Bright Galaxies (RC3) with some simplifications. We do not distinguish the stages of ellipticals and lenticulars. The ring and lens features in spiral galaxies are also neglected in the present classification. However, we distinguish the sub-types of dwarf elliptical-like galaxies, such as dwarf ellipticals (dE), dwarf spheroidals (dSph), and dwarf lenticulars (dS0). We also note the presence of nucleation in these galaxies. The blue-cored dwarf ellipticals (dE_{bc}) and blue dwarf elliptical galaxies (dE_{blue}) are considered as separate sub-types. We distinguish the dwarf irregular galaxies (dI) from the Magellanic type irregulars (Im) and blue compact dwarfs (BCDs).

3. MORPHOLOGY CENSUS OF THE LOCAL GALAXIES

We summarize the basic statistics of the morphology of the local galaxies in Table 1, along with their mean luminosity (M_r) and color ($u - r$). We use the distance of galaxies calculated from the recession velocity relative to the centroid of the Local Group (V_{LG}) to calculate M_r with a Hubble constant of 75km/s/Mpc, following Mould et al. (2000). The dominant population of galaxies is the irregular galaxies ($\sim 43\%$), which are mostly

Table 1
FREQUENCY, M_r AND $u - r$ OF THE LOCAL GALAXIES

Type	N	M_r	$u - r$
E	76	-19.3 ± 1.44	2.60 ± 0.37
dEs ^a	1094	-15.2 ± 1.66	1.74 ± 0.68
S0	277	-18.9 ± 1.25	2.35 ± 1.05
Sp	1879	-17.7 ± 1.67	1.69 ± 1.46
Irr	2504	-14.9 ± 1.61	1.35 ± 0.67

^a Dwarf elliptical-like galaxies (dE, dE_{bc}, dSph, dE_{blue}, and dS0).

dwarf galaxies. The second most numerous population is spiral galaxies ($\sim 32\%$). Therefore, late type galaxies dominate the local universe. The third most numerous type of galaxies is dwarf elliptical-like galaxies ($\sim 18\%$) which are considered to be early type galaxies although a non-negligible fraction of them have young stellar populations. Lenticular galaxies and elliptical galaxies comprise only $\sim 5\%$ and $\sim 1\%$, respectively, of the local galaxies.

It is also apparent that the fraction of dwarf galaxies (dIs, BCDs and dEs) is similar to that of giant galaxies (E, S0, Sp, and Im). This is due to the observational limit of the SDSS spectroscopic target galaxies which was set to $r = 17.77$, corresponding to $M_r = -15.2$ for galaxies at $z = 0.01$. Although we add ~ 900 galaxies fainter than the SDSS observation limit, the present sample is strongly lacking in dwarf galaxies in the local universe. However, the present sample of local galaxies includes a large number of dwarf galaxies which are sufficient for a detailed analysis of dwarf galaxy morphology. In particular, we are able to distinguish the five sub-types of dwarf elliptical-like galaxies (dEs): dE, dE_{bc}, dSph, dE_{blue} and dS0. The fractions of sub-types are not very different, ranging from $\sim 21\%$ for dE to $\sim 16\%$ for dS0.

Although the luminosity distribution of dwarf galaxies overlaps somewhat with that of giant galaxies, it seems plausible to set $M_r = -16.5$ as the dividing luminosity between giants and dwarfs, at least for the galaxy distances derived from the V_{LG} . This dividing luminosity is similar to the mean luminosity of Sdm galaxies ($M_r = -16.63 \pm 1.15$). The fraction of galaxies fainter than $M_r = -16.5$ is ~ 0.65 which is $\sim 15\%$ greater than the morphologically selected dwarf fractions (dIs, BCDs and dEs).

Fig. 1 shows the distribution of M_r with morphological type. We used numerical type T, which is based on the T code of the Third Reference Catalogue of Bright Galaxies (de Vaucouleurs et al., 1991) (RC3) but with some modification. The T codes of spiral galaxies are the same as those in RC3 but we assign T=-3 for all stage of lenticular galaxies and T=10, T=11, T=12, and T=13 for Im, dI, Im/BCD, and BCD, respectively. The T codes from -6 to -11 are assigned to dwarf elliptical-like galaxies: T=-6 (dE), T=-7 (dE_{bc}), T=-8 (dSPh), T=-9 (dE_{blue}), T=-10 (dS0) and T=-11 (dE/dI). As shown in Fig. 1, the luminosity distribution of local galaxies peaks at elliptical galaxies ($M_r = -19.3$) and decreases almost monotonically toward late type galax-

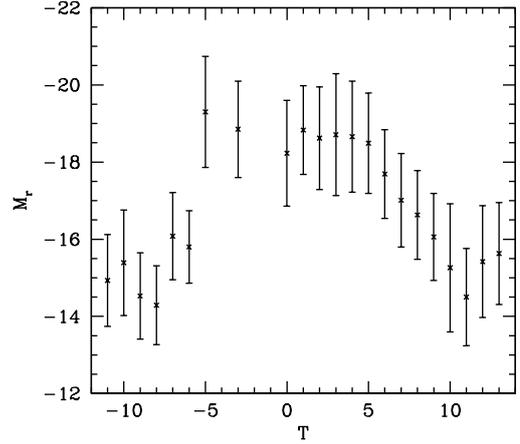


Figure 1. M_r versus T. Morphology of galaxies is represented by numeric code T: dwarf elliptical-like galaxies (T=-11 \sim -6), E (T=-5), S0 (T=-3), Sp (T=0 \sim 9), Irr (T=10, 11), BCD (12, 13).

ies until T=11. The luminosity of dwarf elliptical-like galaxies ranges from $M_r \approx -14$ to $M_r \approx -16$ with the highest luminosity in dE_{bc} galaxies and the lowest luminosity in dSph galaxies. The high luminosity of dE_{bc} galaxies is due to the luminosities of the blue cores. It is also worth noting that dE is ~ 1.5 mag brighter than dSph. The luminosities of BCDs are similar to the bright dwarf ellipticals.

There is also a strong correlation between the Hubble type and $u - r$ color. Elliptical galaxies show the reddest colors while irregular galaxies show the bluest ones. The $u - r$ colors of the dwarf elliptical-like galaxies are similar to those of spiral galaxies. A significant fraction of spiral galaxies show $u - r$ colors strongly reddened by interstellar dust.

4. CONCLUSIONS

The majority of the local galaxies are late type galaxies (Sp & Irr), comprising $\sim 75\%$ of the sample of 5840 galaxies. The fraction of dwarf galaxies is similar to that of giant galaxies. This is due to the observation limit of $r = 17.77$ for the SDSS spectroscopic target galaxies. If we separate galaxies by their luminosity, $\sim 65\%$ of the present sample are dwarf galaxies with a dividing luminosity of $M_r = -16.5$. There is a strong correlation between the morphological types and luminosities of galaxies. Galaxy colors are also well correlated with morphological types.

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