Comparison of Galaxy Structural Decomposition Catalogs and Their Impact on Low Surface Brightness Galaxy Selection (Postprint)

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Abstract

Component decomposition of galaxy surface brightness profiles facilitates understanding of galaxy formation and evolution. Several catalogs of galaxy structural component decomposition based on large-sample galaxy images have been published, which are significant for studying the statistical properties of galaxy structures. However, due to substantial variations in individual fitting results, significant biases arise when selecting low surface brightness galaxies (LSBGs) for small-sample studies. Therefore, investigating the similarities and differences among these catalog results is essential. Based on the galaxy component decomposition catalogs published by Meert et al. (M16 catalog) and Dom´ınguez et al. (MPP-VAC catalog), we compared the results of single-component fitting and two-component decomposition from the two catalogs. The main conclusions are as follows: For the single-component fitting samples, the fitting parameters from the two catalogs are relatively consistent. When comparing the two-component fitting results, we find that in early-type galaxies, aside from the S´ersic index, the consistency of bulge component fitting results between the two catalogs is slightly better than that of the disk component. The average dispersion ratios for half-light radius, surface brightness, and apparent magnitude between bulge and disk components are 0.83, 0.94, and 0.52, respectively; in late-type galaxies, the consistency of disk component fitting results between the two catalogs is significantly better than that of the bulge component. The average dispersion ratios for half-light radius, S´ersic index, surface brightness, and apparent magnitude between bulge and disk components are 4.9, 3, 3, and 4, respectively. The primary cause of the differences in two-component fitting results between the two catalogs is that the MPP-VAC catalog restricts the range of S´ersic index n values during fitting for galaxies whose central pixels are too bright and affect the fitting, thereby making the resulting component decomposition more

reasonable. According to the definition of LSBGs, we find that LSBG candidates constitute 12% of late-type galaxies, among which only 1/4 are identified as LSBGs by both catalogs, while the remaining 3/4 are classified as LSBGs by only one catalog due to differences in fitting results.

Full Text

Preamble

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Comparison of Galaxy Structure Component Decomposition Catalogs and Their Impact on Low Surface Brightness Galaxy Selection

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Abstract

The decomposition of galaxy surface brightness profiles into structural components is essential for understanding galaxy formation and evolution. Several catalogs based on large galaxy samples provide photometric and morphological decompositions, which are crucial for statistical studies of galaxy structures. However, due to significant variations in individual fitting results, selecting low surface brightness galaxies (LSBGs) for small-sample studies can introduce substantial biases. Therefore, comparing these catalogs is necessary. Based on the galaxy decomposition catalogs published by Meert et al. (M16) and Domínguez Sánchez et al. (2021, MPP-VAC), we compare their single-component and two-component (bulge+disk) fitting results. Our main conclusions are: For single-component fits, the results are generally consistent between the two catalogs. For two-component fits in early-type galaxies, the bulge component shows slightly better consistency than the disk component (except for the Sérsic index), with average dispersion ratios of 0.83, 0.94, and 0.52 for half-light radius, surface brightness, and apparent magnitude, respectively. In late-type galaxies, the disk component exhibits significantly better consistency than the bulge component, with average dispersion ratios of 4.9, 3, 3, and 4 for half-light radius, Sérsic index, surface brightness, and apparent magnitude. The primary reason for these differences is that MPP-VAC imposes limits on the Sérsic index n for galaxies with overly bright central pixels, yielding more reasonable decomposition results. Applying the LSBG definition, we find that 12% of late-type galaxies are LSBG candidates, but only one-quarter are identified as LSBGs

by both catalogs; the remaining three-quarters are classified differently due to fitting variations.

Keywords: galaxy structure; component decomposition; structural parameters

1. Introduction

The complex structures of galaxies gradually form through various physical processes such as gas accretion, star formation, disk formation and warping, bar formation and evolution. Since galaxies experience different physical processes at different evolutionary stages, resulting in diverse structures, decomposing and studying these components is vital for understanding galaxy formation and evolution. For instance, the size and properties of galactic bulges can distinguish between classical and pseudo-bulges, providing insights into whether galaxies evolved through major mergers or gradual processes. Additionally, both ΛCDM N-body models and long-term evolution models of bulges demonstrate that the stellar mass distribution between bulge and disk components can constrain galaxy merger trees.

Galaxy structural decomposition requires imaging data. The Sloan Digital Sky Survey (SDSS) Data Release 7 (DR7) provides photometric observations for hundreds of millions of objects and spectroscopic observations for over one million objects. Among these, nearly 700,000 objects classified as galaxies with dust-corrected Petrosian r-band magnitudes between 14 and 17.77 mag are available. Numerous studies have performed surface brightness fitting and decomposition on this sample. The NASA Sloan Atlas (NSA) obtained radial surface brightness profiles using elliptical Petrosian aperture photometry and fitted them with a single component, deriving basic parameters such as magnitude, size, and ellipticity. In 2011, Simard et al. (S11) used Source Extractor (SExtractor) and the GIM2D software package to produce a catalog of single-component and two-component (bulge+disk) decompositions for SDSS DR7 galaxies. In 2016, Meert et al. (M16) used SExtractor and GALFIT to perform single-component and two-component (bulge+disk) surface brightness profile fitting for 670,000 galaxies in SDSS DR7, creating the M16 catalog. Domínguez Sánchez et al. (2021) presented the MaNGA PYMORPH Photometric Value-Added Catalog (MPP-VAC) based on Mapping Nearby Galaxies at Apache Point Observatory (MaNGA) DR17 data, containing 10,293 galaxies with both single-component and two-component (bulge+disk) decomposition results.

These large-sample studies provide excellent descriptions of galaxy structures. Using MPP-VAC, Fischer et al. found that the Sérsic index n of bulge components shows a broad distribution in early-type galaxies with a median of ~4, while late-type galaxy bulges peak near $n = 1$. Kim et al. discovered that most bulge components are red regardless of size. Catalán-Torrecilla et al. used integral field spectroscopy to show that bulge component specific star formation rates (sSFR) quench at stellar masses of $10^{9 \cdot 5}$ M , while disk components quench at $10^{10 \cdot 5}$ M , with both components showing reduced star formation in medium- and high-density environments.

While statistically significant for large samples, these catalogs can yield very different component decomposition results for individual sources due to inherent parameter degeneracies. Such differences can critically impact specific scientific applications. For example, LSBG studies require reliable samples. LSBGs are defined by their disk central surface brightness, typically using $_0$,disk > 22.5 mag·arcsec^{-2} as the classification threshold, though some use 23 mag·arcsec^{-2}. Accurately decomposing and subtracting bulge components is therefore essential for proper LSBG selection. Understanding these catalog differences is necessary when using them to select LSBGs.

Table 1 summarizes the four catalogs (NSA, S11, M16, MPP-VAC). NSA only provides single-component fits without two-component decomposition, so we exclude it from discussion. S11 and M16 have comparable sample sizes but use different software packages; however, S11 overestimated sky background, leading to systematically underestimated galaxy brightness, so we also exclude S11. Although M16 and MPP-VAC differ significantly in sample size, both employ the same decomposition method with single- and two-component (bulge+disk) fitting. Therefore, we focus on comparing M16 and MPP-VAC, examining their g-band single-component and two-component decomposition results and their impact on LSBG selection.

2.1 Common Functions for Radial Surface Brightness Profiles

Radial surface brightness profiles characterize how galaxy surface brightness varies with radius from the center. Several radial distribution functions are commonly used:

(1) Sérsic function. One of the most widely used functions for describing galaxy surface brightness profiles, typically for bulge components:

$$I(r) = I_e \exp\left\{-b_n\left[\left(\frac{r}{R_e}\right)^{1/n} - 1\right]\right\}$$

where R_e is the half-light radius containing half the total galaxy flux, I_e is the surface brightness at R_e, and $b_n = 1.9992n - 0.3271$. The Sérsic index n is often called the concentration parameter. Larger n values produce steep inner profiles and extended outer wings, while smaller n values yield flatter inner profiles and sharp truncation at larger radii. Figure 1 [Figure 1: see original paper] illustrates how the Sérsic profile changes with n; larger n produces steeper inner and more extended outer profiles.

(2) de Vaucouleurs function. Often used for early-type galaxies or bulge components, this is a special case of the Sérsic function with $n = 4$ (i.e., $b_n = 7.669$).

(3) Exponential function. Commonly used for disk components, this is the Sérsic function with $n = 1$:

$$I_{\text{Exp}}(r) = I_{0,d} \exp\left(-\frac{r}{R_d}\right)$$

where $I_{0,d}$ is the central disk surface brightness and R_d is the disk scale length where brightness drops to $1/e$ of the central value. When $n = 1$, R_e and R_d are related by $R_e = 1.678R_d$.

2.2 Decomposition Method of the M16 Catalog

Meert et al. selected 670,723 galaxies from SDSS DR7 ($14 \leq m_{r,\text{cor}} \leq 17.77$ mag) for surface brightness profile analysis. After point spread function (PSF) correction, they obtained four decomposition results: two single-component fits using de Vaucouleurs and Sérsic functions, and two two-component (bulge+disk) fits using de Vaucouleurs + exponential (DevExp) and Sérsic + exponential (SerExp) combinations. The Sérsic index n was limited to $n \leq 8$, while the exponential function fixed $n = 1$ without specifying which component each function described.

Using the PYMORPH analysis method, M16 performed decomposition on g, r, and i-band images from SDSS DR7, obtaining structural parameters for each band. PYMORPH is a Python-based automated software that calls SExtractor and GALFIT to calculate galaxy structural parameters. The process involves: inputting the galaxy image, using SExtractor to create a mask covering external regions and extract the galaxy image, performing initial analysis to estimate central position and apparent magnitude, then passing these estimates along with the galaxy and PSF images (SDSS provides specific PSF values for each galaxy; average FWHM values are $1.47''$, $1.35''$, and $1.28''$ for g, r, and i bands) to GALFIT for detailed fitting. GALFIT convolves the specified radial profile functions with the PSF and compares them to the observed image, yielding structural parameters for single- or two-component fits.

Figure 2 [Figure 2: see original paper] shows the SerExp two-component fit for MaNGA galaxy 11952-12701 from M16. The bulge has Sérsic index $n_b = 8$ and half-light radius $R_{e,b} = 43.8''$ with a relatively bright bulge component, while the disk has $n_d = 1$, $R_{e,d} = 16.1''$, and central surface brightness $\mu_{0,d} \approx 23.9$ mag $\cdot$ arcsec^{-2}. The residual rms ($\Delta_{\text{rms}} = \sqrt{\sum(\mu_{\text{data}} - \mu_{\text{model}})^2/n}$) between the observed profile (red points) and total model (black line) is 0.176.

2.3 Decomposition Method of the MPP-VAC Catalog

The MPP-VAC catalog performed decomposition on 10,293 MaNGA DR17 galaxies using SDSS DR15 images, providing both Sérsic single-component and SerExp two-component fits. MPP-VAC also used the PYMORPH method on g, r, and i-band images, with average PSF FWHM values of 1.44″, 1.32″, and 1.26″.

Figure 2c shows the MPP-VAC fit for galaxy 11952-12701. In MPP-VAC, the bulge is fit with a smaller Sérsic index ($n_b = 2.1$) and the disk with an exponential function, yielding half-light radii of 4.2″ and 13.2″, respectively. The disk central surface brightness is $\mu_{0,d} \approx 22.5$ mag$\cdot$arcsec^{-2}, indicating a smaller bulge and brighter disk compared to M16. The residual $\Delta_{\rm rms}$ is 0.191, similar to M16.

During SerExp fitting, MPP-VAC limited the Sérsic index range to $0 \leq n \leq 8$. For galaxies affected by overly bright central pixels where n approached the upper limit of 8, the Sérsic profile extended far into the outskirts (see red line in Figure 2), producing unrealistic fits where the bulge dominated even in clearly identifiable disk regions. MPP-VAC therefore re-ran PYMORPH with reduced n limits (first to 3, then to 2 or 1 if necessary), forcing the bulge to dominate only in the inner regions. Consequently, some galaxies in MPP-VAC have bulges described by exponential functions and disks by Sérsic functions with $n < 1$. The catalog retained the re-fit result if it yielded a better χ^2 compared to the original.

3. Comparison of Catalog Results

As described above, M16 contains over 670,000 galaxies while MPP-VAC contains 10,293, with approximately 8,500 galaxies in common. Both use PYMORPH, but differences include: M16' s g-band PSF FWHM is 1.47″ versus MPP-VAC' s 1.44″, and MPP-VAC re-fits galaxies with bright central pixels after limiting the Sérsic index. These factors lead to different decomposition results.

To illustrate these differences, we compare only g-band results (i and r bands show similar patterns). We matched samples for both Sérsic single-component and SerExp two-component fits, removing failed fits (single-component: Sérsic index n = -999; two-component: central surface brightness $\mu_0 < 10$ or > 30 mag$\cdot$arcsec^{-2}) and using only MPP-VAC's high-quality main sample. The final matched samples contain 7,613 galaxies for single-component fits and 6,394 for two-component fits (Table 2). We also matched stellar masses from the MPA-JHU catalog and morphological types (T-Type) from the MDLM-VAC catalog. The T-Type distributions are shown in Figure 3 [Figure 3: see original paper].

3.1 Single-Component Sérsic Sample

The single-component sample contains 7,613 galaxies. To better understand fitting differences, we divided it into early-type (T-Type < 0, 2,548 galaxies) and late-type (T-Type > 0, 5,065 galaxies) subsamples using MDLM-VAC morphological classifications.

Figure 4 [Figure 4: see original paper] compares single-component fitting parameters between M16 and MPP-VAC. The first column shows normalized histograms of parameter consistency for different magnitude ranges; the second and third columns show how consistency varies with apparent magnitude for early- and late-type galaxies. The four rows display differences in Sérsic-fit apparent magnitude (Δm), half-light radius ($\Delta \log R_{50}$), Sérsic index ($\Delta \log n$), and axis ratio ($\Delta \log(b/a)$), all calculated as M16 minus MPP-VAC.

The histograms reveal systematic differences: M16 magnitudes are fainter and R_{50} smaller than MPP-VAC' s, particularly for early-type galaxies (red histograms) independent of magnitude. In contrast, $\Delta \log n$ and $\Delta \log(b/a)$ distributions are symmetric, indicating consistent results without systematic bias, though early-type galaxies show slightly larger dispersion than late-types, and fainter galaxies exhibit poorer consistency (broader distributions).

Comparing early- and late-type consistency (second and third columns) shows that apparent magnitude, Sérsic index, and axis ratio are similar between catalogs and independent of galaxy mass. Early-type galaxies show slightly larger half-light radius dispersion (average $\sigma = 0.07$). Overall, single-component fitting parameters are reasonably consistent for both types.

3.2 Two-Component SerExp Sample

Disk decomposition results directly affect LSBG selection. As Figure 2 shows, galaxy 11952-12701's disk central surface brightness differs by ~1.5 mag$\cdot$arcsec^{-2} between catalogs. Comparing two-component (bulge+disk) results is therefore crucial. We again divide the sample into early-type (T-Type < 0, 2,502 galaxies) and late-type (T-Type > 0, 3,892 galaxies) subsamples.

3.2.1 Early-Type Galaxies

Figure 5 [Figure 5: see original paper] compares SerExp fits for early-type galaxies (ellipticals and lenticulars). Differences (Δ) are M16 minus MPP-VAC, with the first column showing bulge components and the second column disk components.

Disk half-light radius differences ($\Delta \log R_{50,d}$) are slightly larger than for bulges. For bulges (Figure 5a), $\Delta \log R_{50,b}$ correlates with $\Delta \log n_b$: galaxies with larger M16 $R_{50,b}$ also have larger n_b (redder colors). Approximately 56% of galaxies on the $\Delta \log R_{50,b} = 0$ line also have consistent n_b values. The $±1 $ and $±2 $ envelopes are asymmetric, with more M16 values being larger, likely due to MPP-VAC' s re-fitting with reduced Sérsic indices for galaxies with bright central pixels. For disks (Figure 5b), $R_{50,d}$ and n_d show no correlation since most early-type disks are fit with exponential functions ($n_d = 1$).

Bulge Sérsic index differences ($\Delta \log n_b$, Figure 5c) are substantial. Although median $\Delta \log n_b$ is near zero, the average dispersion is 0.21, with asymmetric scatter—more galaxies have $\Delta \log n_b > 0$, indicating M16 tends to produce larger

n_b values, again due to MPP-VAC' s index limiting. Disk Sérsic index differences (Figure 5d) are small (average dispersion = 0.03) because most disks are exponential in both catalogs, though some MPP-VAC galaxies have $n_d < 1$ disks, creating a few points with $\Delta \log n_d > 0$.

Bulge surface brightness at half-light radius (μ_e) differences (Figure 5e) are generally similar (median $\Delta\mu_e = 0$). However, disk central surface brightness differences ($\Delta\mu_0$, Figure 5f) have a median of ~0.6 mag$\cdot$arcsec^{-2}, indicating M16 disks are relatively fainter. Average dispersions are 1.14 and 1.21 mag$\cdot$arcsec^{-2} for bulge and disk, respectively, with larger $\Delta\mu_0$ dispersion for galaxies with larger bulge fractions in M16, reaching up to 10 mag$\cdot$arcsec^{-2}.

Bulge total magnitude differences (Δm_b, Figure 5g) are consistent (median = 0 mag, average dispersion = 0.32 mag) and weakly correlate with $\Delta \log n_b$—larger M16 n_b yields brighter bulges. Disk magnitude differences (Δm_d, Figure 5h) have a larger average dispersion of 0.61 mag, with differences up to 5 mag, despite most disks being exponential ($n_d = 1$) in both catalogs.

Overall, except for the small n_d differences due to exponential disk fitting, early-type galaxies show marginally better consistency in bulge parameters. The average dispersion ratios for bulge-to-disk half-light radius, surface brightness, and apparent magnitude are 0.83, 0.94, and 0.52, respectively.

3.2.2 Late-Type Galaxies

Late-type galaxies (T-Type > 0) include Hubble types from Sa to Irr. Figure 6 [Figure 6: see original paper] compares SerExp fits for late-type galaxies.

Bulge half-light radius differences ($\Delta \log R_{50,b}$, Figure 6a) show most galaxies cluster near $\Delta \log R_{50,b} = 0$ with consistent n_b (green points), but the average dispersion is large (0.88), with many M16 values being larger—again likely due to MPP-VAC' s re-fitting. Disk half-light radius differences ($\Delta \log R_{50,d}$, Figure 6b) have a much smaller average dispersion of 0.18.

Bulge Sérsic index differences (Figure 6c) are substantial (average dispersion = 0.42), with asymmetric scatter toward $\Delta \log n_b > 0$. A concentration appears near $\Delta \log n_b = 0.9$ because M16 allows n up to 8 for bright central pixels, while MPP-VAC reduces the limit, sometimes to $n = 1$ (exponential). Disk Sérsic index differences (Figure 6d) are smaller (average dispersion = 0.14), though some MPP-VAC galaxies have $n_d < 1$ disks.

Bulge surface brightness differences ($\Delta\mu_e$, Figure 6e) have a median near zero but large average dispersion (3.31 mag$\cdot$arcsec^{-2}). Disk central surface brightness differences ($\Delta\mu_0$, Figure 6f) have a median of ~0.5 mag$\cdot$arcsec^{-2} (M16 disks fainter) and smaller dispersion (1.09 mag$\cdot$arcsec^{-2}). Galaxies with large μ_e differences (blue-purple points) tend to have low bulge fractions in M16.

Bulge magnitude differences (Δm_b, Figure 6g) have large dispersion (average = 1.73 mag), correlating with M16' s larger n_b values. Disk magnitude differences

(Δm_d, Figure 6h) are smaller (average dispersion = 0.41 mag).

In contrast to early-type galaxies, late-type galaxies show large differences in two-component decomposition, particularly for bulge parameters. The average bulge-to-disk dispersion ratios for half-light radius, Sérsic index, surface brightness, and apparent magnitude are 4.9, 3, 3, and 4, respectively, likely because bulges are generally faint in late-type galaxies.

3.3 Consistency Between Single- and Two-Component Sérsic Indices

Both catalogs provide single- and two-component fits for each galaxy. Can a single Sérsic function adequately describe the radial surface brightness profile? Comparing the single-component Sérsic index n_s with the two-component bulge index n_b provides insight.

Figure 7 [Figure 7: see original paper] compares these indices. For early-type galaxies (Figure 7a), both catalogs show good consistency between n_s and n_b (medians near zero), indicating that single-component fits trace overall structure well. Table 3 shows that MPP-VAC has a slightly larger n_s/n_b ratio than M16, likely because MPP-VAC reduces n_b for galaxies with bright centers.

For late-type galaxies (Figure 7b), consistency is much poorer—only ~50% have $|\log(n_s/n_b)| \leq 0.3$. M16' s median is below zero (27% have $\log(n_s/n_b) < -0.3$), while MPP-VAC' s median is slightly above zero (39% have $\log(n_s/n_b) > 0.3$). The distribution shows a clear bimodal structure with a second peak at $\log(n_s/n_b) \approx -0.9$, arising because two-component fits use the bulge to describe only the central high-contrast structure, allowing n_b to approach the upper limit of 8. MPP-VAC' s peak is smaller due to its reduced n_b limits, yielding larger overall n_s/n_b ratios.

4.1 Comparison of Disk Central Surface Brightness

Special target selection often depends on disk central surface brightness—for example, LSBGs are typically defined as galaxies with g-band disk central surface brightness $\mu_{0,g} > 22.5$ mag · arcsec^{-2}. Therefore, disk decomposition directly affects LSBG selection. We calculate disk central surface brightness from catalog parameters (Sérsic index n_d, half-light radius $R_{e,d}$, and apparent magnitude m_d).

For Sérsic-function disks:

$$I(r) = I_0 \exp\left\{-b_n\left[\left(\frac{r}{R_e}\right)^{1/n} - 1\right]\right\}$$

where I_0 is central surface brightness, R_e is the catalog half-light radius, $b_n = 1.9992n - 0.3271$, and $n = n_d$. Integrating to obtain total magnitude:

$$m_d = -2.5 \log \int_0^\infty 2\pi r I(r) dr$$

From these equations, we solve for I_0 and obtain central surface brightness:

$$\mu_0 = -2.5 \log I_0$$

For exponential disks ($n_d = 1$), this simplifies to:

$$\mu_{0,d} = m_d + 2.5 \log(2\pi R_d^2)$$

where $R_d = R_e/1.678$.

Assuming optically thin disks, we apply inclination corrections:

$$\mu_{0,\mathrm{cor}} = \mu_{0,d} + 2.5 \log(b/a) - 10 \log(1+z)$$

where b/a is the disk axis ratio and z is redshift.

Figure 8 [Figure 8: see original paper] shows disk magnitude differences between catalogs. Histograms (Figures 8a,b) reveal that most galaxies have consistent disk magnitudes: 60% of early-types and 68% of late-types have $|m_{d,\mathrm{M16}} - m_{d,\mathrm{VAC}}| \leq 0.15$ mag, while only 6% and 3% have differences >1 mag.

Figures 8c,d compare disk central surface brightness. For early-types (Figure 8c), 56% have $\mu_0 > 22.5$ mag · arcsec^{-2} in both catalogs, while 24% have $\mu_0 < 22.5$ mag · arcsec^{-2} in both. For late-types (Figure 8d), only 3% are fainter than 22.5 mag · arcsec^{-2} in both catalogs, while 88% are brighter in both. Thus, few late-type galaxies are LSBGs in both catalogs, with 9% showing contradictory classifications.

4.2 LSBG Classification

MPP-VAC' s limited Sérsic index fitting for galaxies with bright central pixels produces different results from M16, affecting classification of special galaxy types. LSBGs are defined by g-band disk central surface brightness $\mu_{0,g} > 22.5$ mag · arcsec^{-2}. Figure 8d shows that 88% of late-type galaxies are brighter than this threshold in both catalogs. Among the remaining 12%, only one-quarter are LSBGs in both catalogs; three-quarters are classified differently.

Table 4 summarizes LSBG classification differences in late-type galaxies. Figure 9 [Figure 9: see original paper] shows examples. Galaxy 8156-12702 (Figures 9a-c) is an LSBG in both catalogs—a faint spiral with spiral arms. M16 fits it with $n_b = 2.8$ bulge and exponential disk (B/T = 0.05), while MPP-VAC uses an exponential bulge and $n_d < 1$ disk, yielding smaller half-light radii. Both fits produce faint disks ($\mu_0 > 22.5$ mag • arcsec^{-2}), with MPP-VAC showing smaller residuals.

Galaxy 11872-6104 (Figures 9d-f) is an LSBG only in M16. This bright-bulged spiral with prominent arms is fit by M16 using $n_b = 3.3$ Sérsic bulge plus faint exponential disk ($\mu_{0,d} = 24.5$ mag • arcsec^{-2}, B/T = 0.64). MPP-VAC limits the Sérsic index, reducing B/T to 0.38 with a smaller bulge ($n_b = 2.1$, $R_{e,b} = 3.5''$) and brighter disk. Both fits have similar residuals, but MPP-VAC' s description is more physically reasonable.

Galaxy 8568-12702 (Figures 9g-i) is an LSBG only in MPP-VAC. This diffuse spiral with arms is fit by M16 with a small bulge ($n_b = 2.4$, $R_{e,b} = 4.0''$) and bright, extended exponential disk ($R_{e,d} = 11.6''$, B/T = 0.08). MPP-VAC' s limited Sérsic index fit yields an exponential bulge ($R_{e,b} = 6.0''$) and fainter disk (B/T = 0.39), with better residuals.

Edge-on galaxies like 9193-12705 (Figures 9j-l) show large differences due to dust lanes. M16 produces a very large bulge ($R_{e,b} = 50.4''$), while MPP-VAC yields a brighter disk but larger residuals. Due to dust uncertainties, edge-on galaxies should be re-fit individually rather than using catalog results.

Comparing the two-dimensional GALFIT reconstructions of galaxy 11952-12701 (Figure 10 [Figure 10: see original paper]) confirms that MPP-VAC' s smaller, fainter bulge and brighter, slightly more extended disk produce smaller residuals and better disk fitting.

Based on these comparisons, we adopt MPP-VAC' s SerExp two-component fits to select LSBGs, excluding edge-on galaxies ($b/a > 0.7$) and selecting disks with $\mu_{0,g} > 22.5$ mag • arcsec^{-2}, yielding 128 LSBGs.

5. Summary and Outlook

This paper compares two galaxy decomposition catalogs—M16 and MPP-VAC —matching them to create two common samples: a Sérsic single-component sample (7,613 galaxies) and a SerExp two-component sample (6,394 galaxies). After detailed comparison of g-band fitting results, our main conclusions are:

1. **Single-component Sérsic fits**: For both early- and late-type galaxies, apparent magnitudes, Sérsic indices, and axis ratios are similar and independent of galaxy mass. Early-type galaxies show slightly larger half-light radius dispersion than late-types. Overall, single-component parameters are consistent between catalogs.
2. **Two-component SerExp fits**: In early-type galaxies, most disks are fit with exponential functions, so bulge Sérsic index differences are large while disk half-light radius, central surface brightness, and magnitude differences are moderate. The average bulge-to-disk dispersion ratios for half-light radius, surface brightness, and magnitude are 0.83, 0.94, and 0.52. When M16 produces larger bulge n_b, it also yields larger $R_{e,b}$ and brighter bulge

magnitudes. In late-type galaxies, bulge parameter dispersions (half-light radius, Sérsic index, surface brightness, magnitude) are significantly larger than disk dispersions, with average ratios of 4.9, 3, 3, and 4, indicating much better disk consistency. This likely reflects the faint nature of bulges in late-type galaxies.

3. **Single- vs two-component consistency**: In early-type galaxies, single-component Sérsic indices n_s and two-component bulge indices n_b show good consistency (80% trace overall structure well). In late-type galaxies, ~50% show clear differences between n_s and n_b, making single-component fits poor tracers. A second peak appears at $\log(n_s/n_b) \approx -0.9$ due to bright central structures forcing n_b toward the upper limit of 8 in two-component fits.

4. **Disk central surface brightness**: Most early- and late-type galaxies have consistent disk magnitudes between catalogs. Applying LSBG criteria, 12% of late-type galaxies are LSBG candidates, but only one-quarter are LSBGs in both catalogs; three-quarters are classified differently.

Examining galaxies with large disk central surface brightness differences shows that MPP-VAC generally produces smaller residuals than M16. After excluding edge-on galaxies, we selected 128 LSBGs using MPP-VAC.

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Note: Figure translations are in progress. See original paper for figures.