Single and two-component galaxy decompositions for Spectroscopic SDSS galaxies and Automated Identification of Preferred Fitting Models: The Electronic Tables

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Abstract

We present a description of the electronic tables for the catalogue of two-dimensional, PSF-corrected deVacouleur's, Sersic, deVacouleur's+Exponential, and Sersic+Exponential fits of $\sim 7 \times 10^5$ spectroscopically selected galaxies drawn from the SDSS DR7. Fits are performed for the SDSS r band utilizing the fitting routine `Galfit` and analysis pipeline `PyMorph`. Tables are distributed in `FITS` format.

1 Introduction

This is the supplement to Meert, Vikram & Bernardi (2014) (hereafter M14) and describes the electronic data supplements of the M14 catalogue. The terms of use for this catalogue are 1) cite M14 in any work using this catalogue and 2) contact the authors via email and inform us of your use of the catalogue. The primary data is presented in Section 2, which describes the UPenn_PhotDec_nonParam_rband table and the UPenn_PhotDec_Models_rband table. We currently release the r-band fits to the `Dev`, `Ser`, `DevExp`, and `SerExp` models. An additional "best fit" catalogue containing a mixture of `Ser` (for pure bulges and disks) and `SerExp` (for all other galaxies) is included. The type of galaxy is determined by the `SerExp` flagging.

We also provide a large amount of ancillary data selected from several value-added SDSS catalogues and external data sources. Section 3 describes ancillary data from SDSS and Galaxy Zoo. Section 4 describes ancillary data from the BAC morphology catalogue of Huertas-Company et al. (2011). Section 5 describes the methodology used to calculate the derived ancillary data including cosmological distances and k-corrections.

We recommend downloading these files when using the catalogue:

1. "UPenn_PhotDec_nonParam_rband.fits" ($\sim$ 49MB) for non-parametric measurements
2. "UPenn_PhotDec_Models_rband.fits" ($\sim$ 474MB) for the `PyMorph` fits
3. "CAST.fits" ($\sim$ 79MB) for redshift, spectroscopic information, and the minimum necessary identifiers needed for cross-matching to SDSS and other catalogues

The total download footprint is $\sim$ 600MB. For convenience, we package these tables, as well as the current document into the $\sim\ 360MB$ "Meert2014_v1.tgz" gzipped tarball. Users can download this tarball or download the catalogues piece by piece. Additional catalogues can be individually downloaded.

2 Model Tables

The UPenn_PhotDec_nonParam_rband table contains the model-independent data from our `PyMorph` fits. The model-dependent fitting parameters are stored in the UPenn_PhotDec_Models_rband table which contains tables for each model ("best fit", `Dev`, `Ser`, `DevExp`, and `SerExp`, in that order) for our catalog. The tables are available in `FITS` format. Any data that was not present is represented by value -999.

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Column Num	Column Name	Explanation	Data Type
0	SexMag	the SExtractor magnitude (mag)	float
1	SexMagErr	the SExtractor magnitude error (mag)	float
2	SexHrad	the SExtractor halflight radii (arcsec)	float
3	SexSky	the SExtractor sky brightness (mag/arcsec^2)	float
4	num_targets	the number of targets	int
5	num_neighborfit	the number neighbor sources fitted with `Ser` profiles	int
6	C	the Concentration	float
7	C_err	the Concentration error	float
8	A	the Asymmetry	float
9	A_err	the Asymmetry error	float
10	S	the Smoothness	float
11	S_err	the Smoothness error	float
12	G	the Gini coefficient	float
13	M20	the M_{20} value	float
14	extinction	The SDSS-provided galactic extinction (magnitude)	float
15	dismod	the calculated distance modulus	float
16	kpc_per_arcsec	the angular scale (kpc/arcsec)	float
17	Vmax	the Volume used for Vmax corrections (Mpc^3)	float
18	SN	the average S/N per pixel inside the halflight radius	float
19	kcorr	k-correction calculated using the SDSS model magnitudes	float

Table 1: The explanation of columns in the table extension 1. These data are the model-independent portion of the data fitted using `PyMorph`. Unfit parameters or missing data are replaced with values of -999.

Column Num	Column Name	Explanation	Data Type
0	m_tot	total fitted apparent magnitude	float
1	BT	the B/T (bulge-to-total light ratio) of the fit	float
2	r_tot	the halflight radius (arcsec) of the total fit	float
3	ba_tot	the axis ratio (semi-minor/semi-major of the total fit	float
4	xctr_bulge	the bulge x center (pixels)	float
5	xctr_bulge_err	the bulge x center error (pixels)	float
6	yctr_bulge	the bulge y center (pixels)	float
7	yctr_bulge_err	the bulge y center error (pixels)	float
8	m_bulge	the bulge magnitude	float
9	m_bulge_err	the bulge magnitude error	float
10	r_bulge	the bulge radius (arcsec)	float
11	r_bulge_err	the bulge radius error (arcsec)	float
12	n_bulge	the Sérsic index	float
13	n_bulge_err	the Sérsic index error	float
14	ba_bulge	the bulge b/a	float
15	ba_bulge_err	the bulge b/a error	float
16	pa_bulge	the bulge position angle (degrees)	float
17	pa_bulge_err	the bulge position angle error (degrees)	float
18	xctr_disk	the disk x center (pixels)	float
19	xctr_disk_err	the disk x center error (pixels)	float
20	yctr_disk	the disk y center (pixels)	float
21	yctr_disk_err	the disk y center error (pixels)	float
22	m_disk	the disk magnitude	float
23	m_disk_err	the disk magnitude error	float
24	r_disk	the disk radius (arcsec)	float
25	r_disk_err	the disk radius error (arcsec)	float
26	ba_disk	the disk b/a	float
27	ba_disk_err	the disk b/a error	float
28	pa_disk	the disk position angle (degrees)	float
29	pa_disk_err	the disk position angle error (degrees)	float
30	GalSky	the `PyMorph` sky brightness (mag/arcsec^2)	float
31	GalSky_err	the `PyMorph` sky brightness (mag/arcsec^2)	float
32	chi2nu	the χ^2/DOF	float
34	finalflag	the primary quality flag described in M14	float
36	autoflag	the intermediate, visually calibrated, automated flag described in M14	float
37	pyflag	the `PyMorph` run flag	float
38	pyfitflag	the `PyMorph` fit flag	float

Table 2: The explanation of columns in the UPenn_PhotDec_Models_rband table extensions. The extensions provide the "best fit", `Dev`, `Ser`, `DevExp`, and `SerExp` fit parameters, respectively. These data are the model-dependent portion of the data fitted using `PyMorph`. Unfit parameters or missing data are replaced with values of -999.

Table 1 provides the non-parametric measurements of galaxies in our catalog. These data are available in the 'UPenn_PhotDec_nonParam_rband.fits' table and include the CASGM measurements (Conselice, 2003; Lotz, Primack & Madau, 2004). We also include `SExtractor` magnitude, halflight radius, and sky brightness estimates. The `num_targets` column indicates the number of sources found within 3″of the center of the image. If this number is larger than 1, then the likelihood of contamination increases substantially. The `num_neighborfits` column indicates the number of neighbor sources fitted simultaneously to the target galaxy. The selection algorithm for simultaneous neighbor fitting is described in M14. Each neighbor is fit with a `Ser` profile, which increases the dimensionality of the fit by 7. If the number of neighbors is larger than 0, then the likelihood of contamination increases substantially. Fitting more than 1 neighbor simultaneously becomes very difficult at our resolution. As such, careful attention should be paid to galaxies with neighbor fits. The flags are designed to catch common problems caused by neighbor fits. The most common problem is contamination of the dimmer component of the two-component fits (either the `DevExp` or `SerExp` fits). While we show that a large number of these problem cases are captured in the catalog, it is likely that a higher rate of contamination is found in these fits with neighbors.

Table 2 provides the parametric measurements of galaxies in out catalog. These data are available in the 'UPenn_PhotDec_Models_rband.fits' table. The extensions 1, 2, 3, and 4 contain the `Dev`, `Ser`, `DevExp`, and `SerExp` fit parameters, respectively. When a fit failed, the values are replaced with -999. Likewise, for single component models, the disk parameters are set to -999. The exception to this is the magnitude, which is set to *positive* 999 to prevent any problems when adding magnitudes together. We provide the value and error terms for each model parameter. Most terms are self-explanatory. The x and y centers may not be very useful in their current form, and should probably be converted to rowc and colc terms.

The tables contain the χ^2_ν for each fit as well as the flag assigned in M14 (the 'finalflag' column). We additionally include the intermediate automated flag (the 'autoflag' column) and the two flags output by `PyMorph` ('pyflag' and 'pyfitflag'). The user will likely not find these additional flags useful as most of the relevant information is contained in the 'finalflag' flag discussed in the main text. Nevertheless, we describe each flag in Section 2.1. We also summarize the recommendations for using the 'finalflag' to select samples in Section 2.2.

2.1 The Quality Flags

There are four quality flags supplied as part of the M14 catalog. The most important of these is the "finalflag". The "finalflag" is used in the main paper and described in Table 3. Since we use this flag throughout the paper, we also provide a breakdown of the percentage of galaxies occupying each category in Table 4.

The "autoflag" contains flags that identify simple problems in the fitting, which we expect to be indicative of unphysical fits. We derive the "autoflag" flags from visual examination and training on a sample of manually classified galaxies. The "autoflags" are described in Table 5. We do not discuss these flags further, as they are incorporated into the "finalflags." However, they are available for use.

Finally, there are two `PyMorph` flags included. The "pyflag" is described in Table 6 and contains diagnostic information regarding the fitting process. The most relevant flag is bit 8 (the NEIGHBOR_FIT) in the "pyflag" which indicates that a neighbor is simultaneously fit and the resulting fit may be biased or unstable because of this neighbor. This flag is effectively available in the num_neighborfit value in the ModTab table along with the additional information of exactly how many neighbors are actually fit. The "pyfitflag" flags can be useful in finding suspect fits, but we do not discuss them here because our finalflag flags supersede these flags. However, when one of the "limit" flags is set in "pyfitflag" flags, it suggests that the convergence of `Galfit` to the best fit was prevented by the fitter encountering the edge of the parameter space. While such flags can indicate problems in the fitting, they can also be harmless (e. g. when the bulge radius goes to 0 and the B/T also approaches 0, the "RE_AT_LIMIT" flag will be set, but we do not expect this to be a bad fit as the fit is telling us that there is no bulge component. If there is no bulge, then we do not care that the bulge parameters are not properly determined.)

2.2 Recommended Flag Usage for Sample Selection

When using the catalogue, we recommend removing galaxies flagged as bad (flag 19) as these galaxies have catastrophically bad estimates of total mag-

Flag Bit	Analysis Flag	Flag Criteria
–	**Trust Total and Component Magnitudes and Sizes**	
10	**Two-Component Galaxies**	
11	No Flags	No Flags are present
12	Good `Ser`, Good `Exp` (Some Flags)	Some automated flags, but nothing bad
13	Flip Components	`Exp` component fitting the inner and `Ser` component fitting the outer part of the profile
–	**Trust Total Magnitudes and Sizes Only**	
1	**Bulge Galaxies**	
2	No `Exp` Component, $n_{\mathtt{Ser}} > 2$	$1000^*(B/T-0.8)^3+(m_{disk}-19)>0.5$ AND $n_{\mathtt{Ser}} \geq 2$
3	`Ser` Dominates Always	$B/T(r) \geq 0.5$ for all r and $n_{\mathtt{Ser}} \geq 2$
4	**Disk Galaxies**	
5	No `Ser` Component	$1000^*(0.2-B/T)^3+(m_{bulge}-19)>0.5$
6	No `Exp`, $n_{\mathtt{Ser}} < 2$, Flip Components	$1000^*(B/T-0.8)^3+(m_{disk}-19)>0.5$ AND $n_{\mathtt{Ser}} < 2$
7	`Ser` Dominates Always, $n_{\mathtt{Ser}} < 2$	$B/T(r) \geq 0.5$ for all r and $n_{\mathtt{Ser}} < 2$
8	`Exp` Dominates Always	$B/T(r) < 0.5$ for all r
9	Parallel Components	$RMS(B/T - \mu(B/T)) : 0 < r < r(0.9L_{tot})$ & $n_{bulge} < 2.0$
14	**Problematic Two-Component Galaxies**	
15	`Ser` Outer Only	$B/T < 0.7$ AND $B/T(r(0.9L_{tot}) > 0.5$ AND $n_{bulge} \geq 2.0$ AND $B/T(0) > 0.5$
16	`Exp` Inner Only	$B/T(0) < 0.5$ AND $B/T(r: r < 2.7r_{hl}) > 0.5$ AND $n_{bulge} \geq 2.0$ AND NOT Ser Outer Only
17	Good `Ser`, Bad `Exp`, B/T>=0.5	$B/T > 0.75$ AND $\Delta\phi > 45$ AND $b/a_{bulge} < 0.75$ AND $b/a_{disk} < 0.4$
18	Bad `Ser`, Good `Exp`, B/T<0.5	$B/T < 0.25$ AND $\Delta\phi > 45$ AND $b/a_{bulge} < 0.4$ AND $b/a_{disk} < 0.75$
26	Bulge is point	Good fit, except that the circularized bulge radius is less than 0.188 arcsec
19	**Bad Total Magnitudes and Sizes**	
20	Centering Problems	(galaxy centroid-sdss galaxy centroid)>0.7^*r_{sex}
21	`Ser` Component Contamination by Neighbors or Sky	$r_{bulge,cir}/r_{sex} > 4.0$
22	`Exp` Component Contamination by Neighbors or Sky	$r_{bulge,cir}/r_{sex} > 4.0$
23	Bad `Ser` and Bad `Exp` Components	Failure of measurements
24	`Galfit` Failure	`Galfit` fails to converge or other failure of the pipeline
25	Polluted or Fractured	CasJobs neighbors not properly masked/masked or target is separated into 2 or more objects

Table 3: The description of our categories as described in the main text.

Flag Bit	Descriptive Category	% Dev	% Ser	% DevExp	% SerExp
–	**Trust Total and Component Magnitudes and Sizes**	0.000	0.000	41.853	38.820
10	**Two-Component Galaxies**	0.000	0.000	41.853	38.820
11	No Flags	0.000	0.000	31.449	19.169
12	Good `Ser`, Good `Exp` (Some Flags)	0.000	0.000	11.673	20.332
13	Flip Components	0.000	0.000	1.364	1.544
–	**Trust Total Magnitudes and Sizes Only**	97.175	96.901	52.305	54.718
1	**Bulge Galaxies**	97.175	58.090	14.574	18.898
2	No `Exp` Component, $n_{\mathtt{Ser}} > 2$	97.175	58.090	4.627	7.047
3	`Ser` Dominates Always	0.000	0.000	9.948	11.851
4	**Disk Galaxies**	0.000	38.811	28.334	24.955
5	No `Ser` Component	0.000	0.000	24.910	16.789
6	No `Exp`, $n_{Ser} < 2$, Flip Components	0.000	38.811	0.000	0.547
7	`Ser` Dominates Always, $n_{\mathtt{Ser}} < 2$	0.000	0.000	0.000	0.105
8	`Exp` Dominates Always	0.000	0.000	3.424	2.849
9	Parallel Components	0.000	0.000	0.000	4.665
14	**Problematic Two-Component Galaxies**	0.000	0.000	9.397	10.865
15	`Ser` Outer Only	0.000	0.000	5.360	7.537
16	`Exp` Inner Only	0.000	0.000	0.516	0.438
17	Good `Ser`, Bad `Exp`, B/T>=0.5	0.000	0.000	0.012	0.018
18	Bad `Ser`, Good `Exp`, B/T<0.5	0.000	0.000	0.875	0.646
26	Bulge is point	0.000	0.000	2.633	2.225
19	**Bad Total Magnitudes and Sizes**	2.825	3.099	5.842	6.462
20	Centering Problems	0.747	0.767	1.013	0.977
21	`Ser` Component Contamination by Neighbors or Sky	1.280	1.591	1.234	2.108
22	`Exp` Component Contamination by Neighbors or Sky	0.000	0.000	2.778	2.381
23	Bad `Ser` and Bad `Exp` Components	0.000	0.000	0.290	0.321
24	`Galfit` Failure	0.187	0.124	0.249	0.355
25	Polluted or Fractured	0.653	0.654	0.652	0.651

Table 4: A breakdown of the finalflags characterized into categories useful for analysis. The first two groups can be used for analysis of total fits. When examining the sub components, consideration should be given as to exactly which groups of fits should be included.

Flag Bit	Flags	Flagging Criteria
0	**Centering**	(galaxy centroid-sdss galaxy centroid)>0.7*r_{sex}
1	**Parallel Components**	$RMS(B/T - \mu(B/T)) : 0 < r < r(0.9L_{tot})$ & $n_{bulge} < 2.0$
2	**No `Ser` Likely**	1000*(0.2-B/T)^3+(m_{bulge}-19)>0.5
3	**No `Exp` Likely**	1000*(B/T-0.8)^3+(m_{disk}-19)>0.5
–	`Ser` **Component Flags**	
4	*`Ser` Contaminated*	$r_{bulge,cir}/r_{sex} > 4.0$ AND $b/a_{bulge} <= 0.6$
5	*`Ser` is Sky*	$r_{bulge,cir}/r_{sex} > 4.0$ AND $b/a_{bulge} > 0.6$
6	*High e `Ser`*	$b/a_{bulge} < 0.4$ AND B/T<0.25
7	*`Ser` PA Problem*	$\Delta\phi > 45$ AND B/T<0.5 AND $b/a_{bulge} < 0.75$ AND $b/a_{disk} < 0.75$
8	*`Ser` Fitting Outer*	B/T< 0.7 AND B/T(r(0.9L_{tot})>0.5
9	*`Ser` is Disk*	$r_b/r_d > 1.5$ AND $n_{bulge} < 2$
10	*`Ser` Dominates Always*	B/T(r) >0.5 : $0 < r < r(0.95L_{tot})$
11	*Low Sersic index `Ser`*	$r_b/r_d \leq 1.5$ AND $n_{bulge} < 2$
–	`Exp` **Component Flags**	
12	*`Exp` Contaminated*	$r_{disk,cir}/r_{sex} > 3.0$ AND $b/a_{disk} <= 0.6$
13	*`Exp` is Sky*	$r_{disk,cir}/r_{sex} > 3.0$ AND $b/a_{disk} > 0.6$
14	*High e `Exp`*	$b/a_{disk} < 0.4$ AND B/T> 0.75
15	*`Exp` PA Problem*	$\Delta\phi > 45$ AND B/T>0.5 AND $b/a_{bulge} < 0.75$ AND $b/a_{disk} < 0.75$
16	*`Exp` Fitting Inner*	B/T(0)<0.5 AND B/T(r: r< 2.7r_{hl}) > 0.5
17	*`Exp` Dominates Always*	B/T(r)<0.5 : $0 < r < r(0.95L_{tot})$
18	**Galfit Failure**	Galfit fails to converge and crashes
19	**Bad Total Fit**	Any of bits 0, 4, 5, 12, 13, 22, 24, or 25 set or at least 2 of bits 2, 3, 10, and 17 set
20	**Bad Disk**	Bits 12 or 13 set or bit 16 and any of bits 1, 8, 9, or 11 set or bit 14 and 15 set or bit 1 set
21	**Bad Bulge**	Bits 4 or 5 set or bit 8 and bits 9 or 16 set or bit 6 and 7 set or bit 1 set
22	**High χ^2**	$\chi^2 > 20$
23	**Flip Components**	At least 2 of bits 9, 8, or 16 set or bits 16 and 11 set or bit 9 set or bits 3 and 11 set
24	**Polluted**	Neighbor expected from SDSS not fitted or masked
25	**Fractured**	Neighbor fitted, but no neighbor exists in SDSS
26	**Tiny Bulge**	$r_{bulge,cir} < 0.188$ arcsec

Table 5: The selection criteria used to define the automated flags. The first column gives the flag bit. The second column gives the flag name, the third column gives the cuts used on fitted parameters to set the flag.

Flag Bit	Flag	Flag Criteria
0	REPEAT	This is a repeated fit
1	FIT_BULGE_CNTR	Bulge center was a fitted parameter
2	FIT_DISK_CNTR	Disk center was a fitted parameter
3	FIT_BULGE	Bulge component was fitted
4	FIT_DISK	Disk component was fitted
5	FIT_SKY	Sky component was fitted
6	FIT_POINT	Point component was fitted
7	FIT_BAR	Bar component was fitted
8	NEIGHBOR_FIT	Neighbor component was fitted
9	EXCEED_SIZE	CASgm module flag for galaxy that extends too far to be measured (i. e., the image is not big enough)
10	NO_TARGET	No target has a `SExtractor` centroid within $3''$of the image center
11	ASYM_NOT_CONV	CASgm module flag for galaxy asymmetry measurement that fails to converge
12	ASYM_OUT_FRAME	CASgm module flag for galaxy asymmetry that extends too far to be measured (i. e., the image is not big enough)
13	ELLIPSE_FAIL	CASgm module flag for failure to generate the mask used by the CASgm module
14	CASGM_FAIL	CASgm module crashes
15	GALFIT_FAIL	`Galfit` crashed
16	PLOT_FAIL	plotting module crashed
17	ERRORS_FAILED	uncertainty on fit parameters incorrectly calculated
18	AVGIE_FAILED	average surface brightness from `SExtractor` incorrectly calculated
19	BACK_FAILED	`PyMorph` fails to measure the background
20	DETAIL_FAILED	detailed fitting procedure failed

Table 6: The selection criteria used to define the `PyMorph` flags. The first column gives the flag bit. The second column gives the flag name, the third column gives a description of the flag. More detailed descriptions can be found in Vikram et al. (2010).

Flag Bit	Flag	Flag Criteria
0	LARGE_CHISQ	$\chi^2_\nu > 2.5$
1	SMALL_GOODNESS	Goodness < 0.60
2	FAKE_CNTR	bulge or disk component moves more than 3 pixels during fitting
3	IE_AT_LIMIT	bulge magnitude approaches ± 7 mag from initial value set by `SExtractor`
4	ID_AT_LIMIT	disk magnitude approaches ± 7 mag from initial value set by `SExtractor`
5	RERD_AT_LIMIT	Not currently used/ no constraint
6	BT_AT_LIMIT	Not currently used/ no constraint
7	N_AT_LIMIT	sersic index approaches 0.1 or 8.0
8	RE_AT_LIMIT	bulge radius approaches 0 or 50 times the `SExtractor` halflight radius
9	RD_AT_LIMIT	disk radius approaches 0 or 50 times the `SExtractor` halflight radius
10	EB_AT_LIMIT	bulge b/a approaches 0 or 1.0
11	ED_AT_LIMIT	disk b/a approaches 0 or 1.0

Table 7: The selection criteria used to define the `PyMorph` fit flags. The first column gives the flag bit. The second column gives the flag name, the third column gives a description of the flag. More detailed descriptions can be found in Vikram et al. (2010).

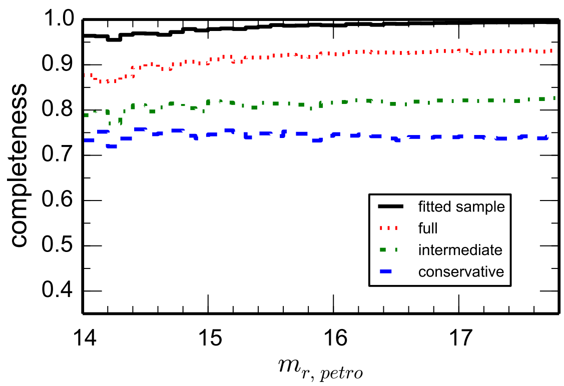

Figure 1: The completeness of the the samples described in Section 2.2. All completeness calculations are relative to the original magnitude-limited galaxy sample downloaded from SDSS DR7.

nitude and radius. Additional galaxies may be removed depending on how conservative the user seeks to be. The problematic two-component fits (flag 14) or the two-component fits with bulge Sersic index n≥8 may be used for total magnitude and radius measurements, but the sub-components are not reliable.

We distribute our fits and flags for each of the four models (`Dev`, `Ser`, `DevExp`, and `SerExp`). In addition, we distribute the preferred catalogue for public use. This preferred catalogue has `Ser` fits provided for galaxies flagged as pure bulge or pure disk. The remaining galaxies have `SerExp` fits.

We suggest one of these composite samples drawn from the preferred fit catalogue described in the previous paragraph:

The conservative catalogue Select all galaxies with final flag bits 11, 12, or 13 set and bulge Sersic index <8. The user should be aware that galaxies with bit 13 set (which were flagged as inverted profiles in the `SerExp` fit) have their B/T inverted and the components reversed relative to the `SerExp` fit. Therefore, no additional alterations must be made when using the preferred fit catalogue. In addition, the user should select galaxies with `SerExp` final flag bits 1 or 4 set. These galaxies will have B/T of 1 (for bulges; final flag bit 1 set) or a B/T of 0 (for disks; final flag bit 4 set) and the relevant `Ser` parameters are reported in the catalogue.

The intermediate catalogue Use the catalogue above plus all galaxies with final flag bit 10 set and bulge Sersic index =8.

The full catalogue Use the catalogue above plus all galaxies with final flag bit 14 set. This is the least restrictive version of the catalogue but may include galaxies with strange, difficult-to-interpret fit parameters.

Figure 1 shows the completeness of the three samples described above. The "fitted sample" represents our selection after the cuts. All completeness calculations are relative to the original magnitude-limited galaxy sample downloaded from SDSS DR7. Not surprisingly, the completeness drops with more conservative catalogue choices. However, the completeness is largely flat across the magnitude range with a slight decrease of order 0.05 at magnitudes brighter than 14.5 extinction-corrected Petrosian r-band magnitude.

The data files for this catalogue are available online at `http://www.physics.upenn.edu/~ameert/SDSS_PhotDec/`. We also provide an interface for generating diagnostic panels that provide postage stamps images of the 2D model and residual as well as the 1D profile. These panels can be generated for a user-uploaded list of galaxies on demand.

3 CAST (SDSS DR7 Spectroscopic Sample CasJobs Data) Table Description

The CasJobs data is divided into two tables, both available in `FITS` format. Any data that was not present in the original table is represented by value -999.

The first table contains, "UPenn_PhotDec_CAST.fits" contains band-independent data used in fitting and analysis. Table 8 describes the structure of the first `FITS` file containing the CAST data. Most rows are self-explanatory. The 0^{th} row contains the `galnum` value, which is the unique identifier used throughout our work to identify galaxies in place of the much longer SDSS `objid`. The user is advised to refer to the `galnum` value when using galaxies in this catalogue. Any references made by the authors to specific galaxies is also done by `galnum`. The `badflag` value reports some of the most relevant flags used to select this sample from SDSS. There are many more flags that are produced by the SDSS photometric pipeline.

Column Num	Column Name	Explanation	Data Type
0	`galnum`	the assigned unique galaxy id number	int
1	objid	the unique SDSS photometric object id	bigint
2	SDSSIAU	the SDSS IAU designation of the source	string
3	badflag	SDSS photometric pipeline flags SATURATED, BRIGHT, EDGE, NODEBLEND, CHILD, and DEBLENDED_AS_PSF	bigint
4	nchild	the number of child sources deblended by the SDSS	int
5	mode	1: primary, 2: secondary, 3: family object, 4: outside chunk boundary	int
6	run	SDSS run number	int
7	rerun	SDSS rerun number	int
8	camCol	SDSS camCol number	int
9	field	SDSS field number	int
10	obj	SDSS object number	int
11	stripe	SDSS stripe number	int
12	startmu	SDSS starting mu for observation of the chunk	int
13	specobjid	the unique SDSS spectroscopic id number	bigint
14	plate	SDSS plate number	int
15	mjd	SDSS mjd of observation	int
16	fiberid	SDSS fiber ID	int
17	ra	right ascension (degrees)	float
18	dec	declination (degrees)	float
19	z	redshift of the galaxy	float
20	veldisp	SDSS measured velocity dispersion (km/s)	float
21	veldispErr	SDSS velocity dispersion error (km/s)	float
22	eclass	SDSS spectroscopic classification	float
23	p_el_debiased	Galaxy Zoo Debiased Probability of Elliptical Galaxy	float
24	p_cs_debiased	Galaxy Zoo Debiased Probability of Spiral Galaxy	float
25	spiral	The raw Galaxy Zoo votes for spiral type	float
26	elliptical	The raw Galaxy Zoo votes for elliptical type	float
27	uncertain	The raw Galaxy Zoo votes for uncertain type	float

Table 8: The explanation of columns in the "UPenn_PhotDec_CAST.fits" table. These data are the band-independent collected from SDSS. The identifying information is also included to allow matching to external catalogues.

Column Num	**Column Name**	**Explanation**	**Data Type**
1	petroR90	The radius (in arcsec) that contains 90% of the Petrosian magnitude	float
2	petroR50	The radius (in arcsec) that contains 50% of the Petrosian magnitude	float
3	petroMag	The Petrosian magnitude	float
4	petroMagErr	The error on the Petrosian magnitude	float
5	ModelMag	The model magnitude	float
6	ModelMagErr	The error on the model magnitude	float
7	devRad	The SDSS `Dev` radius in arcsec	float
8	devab	The SDSS `Dev` axis ratio (semi-minor/semi-major)	float
9	devmag	The SDSS `Dev` magnitude	float
10	devPhi	The SDSS `Dev` position angle (degrees East of North)	float
11	expRad	The SDSS `Exp` radius in arcsec	float
12	expab	The SDSS `Exp` axis ratio (semi-minor/semi-major)	float
13	expmag	The SDSS `Exp` magnitude	float
14	expPhi	The SDSS `Exp` position angle (degrees East of North)	float
15	fracdev	The SDSS fracdev term	float
16	extinction	The SDSS-provided galactic extinction (magnitude)	float
17	aa	The SDSS zeropoint (magnitudes)	float
18	kk	the extinction term used in the conversion of counts to magnitudes (magnitudes)	float
19	airmass	the airmass term used to convert counts to magnitudes	float
20	gain	The SDSS gain (e^-/DN)	float
21	darkvariance	The SDSS dark variance term used in fitting	float
22	sky	The SDSS sky level in magnitude/arcsec^2	float
23	skyErr	The uncertainty in the SDSS sky level in magnitude/arcsec^2	float
24	psfWidth	The psfWidth in arcsec reported by SDSS	float
25	rowc	The rowc of the centre of the galaxy in the SDSS frame	float
26	colc	The colc of the centre of the galaxy in the SDSS frame	float

Table 9: The explanation of columns in the CAST table extensions 2-4. These data are the band-dependent portion of the data collected from SDSS. Extension 2 contains data for the g-band, extension 3 for the r-band, and extension 4 for the i-band.

Additional flags can be extracted from the SDSS data by the user.

We also provide both the raw (`spiral`, `elliptical`, and `uncertain`) as well as the debiased (`p_el_debiased` and `p_cs_debiased`) Galaxy Zoo parameters. These probabilities are selected from the Galaxy Zoo catalogue stored on the SDSS CasJobs server. The Galaxy Zoo project provides visual classifications for many of the galaxies in our catalogue. Classification was done by citizen-scientists and corrected for bias by the Galaxy Zoo science team. The project is described in Lintott et al. (2008) and the data release is described in Lintott et al. (2011).

Additionally, the Galaxy Zoo classification for each galaxy is collected for use in analysis. These probabilities are selected from the Galaxy Zoo catalogue stored on the SDSS CasJobs server. The Galaxy Zoo project provides visual classifications for many of the galaxies in our catalogue. Classification was done by citizen-scientists and corrected for bias by the Galaxy Zoo science team. The project is described in Lintott et al. (2008) and the data release is described in Lintott et al. (2011).

Table 9 describes the CASTmodels table for the sample from SDSS DR7 and is available in `FITS` format with the file name "UPenn_PhotDec_CASTmodels.fits". This table contains the the SDSS parametric and non-parametric measurements of the target galaxy, including Petrosian, `Dev`, `Exp` and ModelMag fits. It also contains the galactic extinction and calibration information used to convert from counts to magnitudes. The calibration parameters are used after fitting to convert from DN to magnitudes following standard SDSS conventions[1]. SDSS fits a single component `Dev` model and a single component `Exp` model to each galaxy. These models are included here and are compared to our fits in the main paper. SDSS also reports a `ModelMag` which is simply the better of the `Dev` or `Exp` fits. SDSS also reports a Cmodel magnitude[2], which can be calculated from this data using the `fracdev` parameter using the simple equation:

$$\mathrm{F_{Cmodel}} = \mathrm{fracDeV} * \mathrm{F_{deV}} + (1 - \mathrm{fracDeV}) * \mathrm{F_{exp}} \quad (1)$$

Where the F terms are the flux of the respective models. The magnitude is then $-2.5 log_{10}(\mathrm{F_{Cmodel}})$.

[1] See `http://www.sdss.org/dr7/algorithms/fluxcal.html` for the SDSS documentation and further discussion.

[2] See `http://www.sdss.org/dr7/algorithms/photometry.html` for the SDSS documentation and further discussion.

4 H2011 (Morphology 2010) Table

This table includes data from the corresponding entries in the Morphology 2010 catalogue produced by Huertas-Company et al. (2011). The Morphology 2010 catalogue published for public is available for download at `http://gepicom04.obspm.fr/sdss_morphology/Morphology_2010.html`. The catalogue presents an automated morphological classification in 4 types (E,S0,Sab,Scd) of 700,000 galaxies from the SDSS DR7 spectroscopic sample based on support vector machines. It provides probabilities of each type as well as a probability of early type (E or S0). The spectra are also classified according to Sánchez Almeida et al. (2010) with the so-called ASK classes 0-27. These classify galaxy spectra according to stellar population age and emmissive properties of active galaxy types.

The data matched to our SDSS DR7 sample is available in fits table format. Any data that was not present in the original table is represented by value -999.

5 Derived Values Included in the Tables

Table 1 includes distances and k-corrections. The k-corrections are calculated using `kcorrect v4.2` For these calculations, we assume a flat cosmology with (H_0,Ω_Λ,Ω_m) =(70 km s^{-1}Mpc^{-1}, 0.7, 0.3).

5.1 K-Corrections

K-corrections are calculated using the version 4 of the K-correction code `kcorrect` described in Blanton & Roweis (2007). To calculate the k-correction, the SDSS `modelmag` and `modelmag_err` are used and data for all bandpasses (u,g,r,i,z) are provided to the program. The resulting k-corrections and additional measured or calculated qualities are stored in the Derived Parameters Table (hereafter DERT) which is also distributed with the catalog.

5.2 Rest-Frame Conversion Parameters

We calculate a distance modulus, DM, and angular diameter distance, D_A, in Mpc according to the usual

Column Num	Column Name	Explanation	Data Type
0	`galnum`	the assigned unique galaxy id number	int
1	id_marc	the unique ID number in the Morphology 2010 catalogue	int
2	specObjID_marc	the specObjID matched to the value in the CAST table	bigint
3	ra	the right ascension in the Morphology 2010 catalogue	float
4	dec	the declination in the Morphology 2010 catalogue	float
5	z	the redshift in the Morphology 2010 catalogue	float
6	probaE	the probability of being Early type (E or S0)	float
7	probaEll	the probability of being Elliptical	float
8	probaS0	the probability of being S0	float
9	probaSab	the probability of being Sab	float
10	probaScd	the probability of being Scd	float
11	ask_class	the spectral class from Sánchez Almeida et al. (2010)	float

Table 10: The explanation of columns in the H2010 table extension 1. These data are the band-independent portion of the data. There is no band-specific detail.

equations:

$$D_M(z) = \frac{c}{H_0}\int_0^z \frac{dz'}{\sqrt{\Omega_M(1+z)^3+\Omega_\Lambda}}, \tag{2a}$$

$$D_A(z) = \frac{D_M}{1+z}, \tag{2b}$$

$$D_L(z) = (1+z)D_M, \tag{2c}$$

$$\mathrm{DM} = 5log\,(D_L) + 25 \tag{2d}$$

where we have adopted the notation given in Hogg (1999). The angular diameter distance is reported in the DERT in units of kpc per arcsec to allow for easy conversion between apparent and physical sizes of galaxies.

5.3 V_{Max} Correction for Selection Effects

We calculate a V_{Max} term for each galaxy representing the observable volume given the constraints on magnitude, surface brightness, and redshift used to construct the catalog. cuts on apparent magnitude, apparent surface brightness and galaxy redshift to select our sample. Volume corrections are calculated similar to that of Shen et al. (2003) and essentially the same as Simard et al. (2011) (i. e., we account for all of the catalog cuts when calculating the observed volume for any galaxy in the catalog). As discussed in M14, the SDSS spectroscopic survey is complete down to a galactic extinction corrected Petrosian r-band magnitude of 17.77 and an extinction corrected Petrosian r-band surface brightness of 23.0 mag/arcsec^2. Additionally, we imposed a minimum redshift cut of $z_{\min} > 0.005$ to ensure that the redshifts are not polluted by the peculiar velocities and a maximum redshift cut of $z_{\min} < 1.0$. This upper redshift cut is included to prevent any strange objects from being included in the catalog. It removes essentially no galaxies and changes the V_{Max} value of less than 10 galaxies. We also include a minimum magnitude cut to exclude bright galaxies. Therefore, we must calculate the volume in which any particular galaxy is observable.

The lower and upper bounds of redshift that limit this volume are determined by the conditions imposed on the data. The magnitude limits in the r-band, $m_{r,\min} \leq m_{r,\mathrm{obs}} \leq m_{r,\max}$ correspond to a lower and upper limit on the redshift at which the galaxy remains observable through the luminosity distance.

$$D_L(z_{\max,m}) = D_L(z)10^{-0.2(m_r - m_{r,\max})}, \tag{3a}$$

$$D_L(z_{\min,m}) = D_L(z)10^{-0.2(m_r - m_{r,\min})} \tag{3b}$$

The surface brightness limit constrains V_{Max} mainly through the $(1+z)^4$ cosmological dimming effect. The maximum redshift from which a galaxy with mean surface brightness $\mu_{50,r}$ at redshift z can be detected at the surface brightness limit of $\mu_{50,r} = 23$ is given by

$$z_{\max,\mu} = (1+z)10^{(23.0-\mu_{50,r})/10} - 1 \tag{4}$$

As is mentioned by Simard et al. (2011), our selection criteria do not include a cut on size of the target galaxy, so the maximum redshifts may differ from that of Shen et al. (2003). The maximum and minimum redshifts for a galaxy in our catalog are then

$$z_{\min} = \max(z_{\min,m}, 0.005), \tag{5a}$$

$$z_{\max} = \min(z_{\max,m}, z_{\max,\mu}, 1.0) \tag{5b}$$

With the above limits on redshift, we can then compute the comoving volume in which our target galaxy satisfies the sample selection criteria:

$$\mathrm{V_{Max}} = \int d\Omega f(\theta,\phi) \int_{z_{\min}(\theta,\phi)}^{z_{\max}(\theta,\phi)} \frac{(1+z)^2 D_A^2}{H(z)} c dz \tag{6}$$

where $H(z)$ is the Hubble parameter at redshift z and c is the speed of light. $f(\theta, \phi)$ is the sampling fraction of point (θ, ϕ) on the sky, and Ω is the solid angle. Following Simard et al. (2011), we take $f(\theta, \phi)$ to be constant. In our case of a flat universe, Equation 6 reduces to

$$\mathrm{V_{Max}} = \frac{4\pi f_{sky}}{3}(D_M(z_{\max})^3 - D_M(z_{\min})^3) \tag{7}$$

where $f_{sky} = 0.195$ is the fraction of the full sky covered by SDSS (8032 square degrees coverage for the SDSS DR7 Legacy survey out of 41253 square degrees in the sky). We provide our calculated values of $\mathrm{V_{Max}}$ in the DERT.

6 Data to be added

We will be expanding the catalogue to the i and g bands soon. We will also be providing information on these sources from GALEX, UKIDSS, the Yang Halo Catalogue, the MPA-JHU masses and star formation rates, and matches to MaxBCG.

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