A Sample of E+A Galaxy Candidates in LAMOST Data Released 2

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Abstract

A sample of 70 E+A galaxies are selected from 37,206 galaxies in the second data release (DR2) of Large Sky Area Multi–Object Fiber Spectroscopic Telescope (LAMOST) according to the criteria for E+A galaxies defined by Goto (2004), and each of these objects is further visually identified. In this sample, most objects are low redshift E+A galaxies with z < 0.25, and locate in the high latitude sky area with magnitude among 14 to 18 mag in g, r and i bands. A stellar population analysis for the whole sample indicates that the E+A galaxies are characterized by both young and old stellar populations (SPs), and the metal–rich SPs have relatively higher contributions than the metal–poor ones. Additionally, a morphological classification for these objects is performed based on the images taken from the Sloan Digital Sky Survey (SDSS).

Key words: galaxies: evolution — galaxies: formation — galaxies: interactions — galaxies: peculiar — galaxies: starburst.

1 INTRODUCTION

E+A galaxies, with strong Balmer absorption lines and little or no nebular emissions in their optical spectra, are widely considered as short–lived but potentially important phase in galaxy evolution (Leiva & Galaz, 2015).
The strong Balmer absorption lines (such as Hδ) indicate that the stellar population is dominated by A–type stars which must have formed within the last ~ 1 Gyr. However, the lack of optical emission lines (such as Hα, [O ii]) implies that star formation is not ongoing in the galaxies. A general interpretation of this spectral feature is that these galaxies are observed in the post–starburst phase (e.g. Dressler & Gunn 1983; Couch & Sharples 1987; Poggianti et al. 1999; Goto et al. 2003; Goto 2007b). While there are still some questions about this view, for example, they may also be produced by the abrupt truncation of star formation in a disc, without necessarily requiring a starburst (e.g. Shioya et al. 2004; Bekki et al. 2005). A lot of works were dedicated to investigate the physical mechanisms such as galaxy mergers (Mihos & Hernquist, 1996; Bekki et al., 2005), interaction of physical pairs (Yamauchi et al., 2008; Matsubayashi et al., 2011; Bekki et al., 2005), interactions with cluster tidal field (Poggianti & Wu, 2000; Bekki et al., 2001) or intra–cluster medium (Bothun & Dressler, 1986). However, the real scenario that can explain such galaxies is still uncertain.

In order to deeply understand the physics of E+A galaxies, enough E+A galaxy samples are needed. However, one of the major difficulties is their rarity (Goto et al., 2003), and only sky surveys can provide the possibility of finding them. Recently, a catalog of E+A galaxies were identified by Goto (2007a) from SDSS (the Sloan Digital Sky Survey) DR5, which includes 564 objects. Seven very local E+A galaxies with 0.0005 < z < 0.01 were discovered by Pracy et al. (2012) in SDSS DR7. In this paper, we present a sample of 70 local E+A galaxies carefully selected from LAMOST DR2 (Cui et al., 2012; Zhao et al., 2012). This sample, together with available catalogs, can be used for statistical analyses and follow–up observations in multi–wavelength.

The paper is organized as follows. In Section 2, sample selection and auto–search method are described in details, and how to identify the E+A galaxies are presented. A preliminary discussion about this sample is shown in Section 3, including the space distribution, stellar population, and image analysis. Finally, a summary is given in Section 4.

2 THE E+A GALAXY SAMPLE

2.1 LAMOST dataset

The Large Sky Area Multi–Object Fiber Spectroscopic Telescope (LAMOST, also called the Guo Shou Jing Telescope) is a special reflecting Schmidt telescope with an effective aperture of 3.6 — 4.9 m and a field of view of 5°. It is equipped with 4000 fibers, with a spectral resolution of R ≈ 1800 and the wavelength ranging from 3800 to 9000 Å (Cui et al., 2012; Zhao et al., 2012). The LAMOST DR2, based on the pilot survey from 2011 October to 2012 June and the general survey from 2012 September to 2014 June, contains more than four million spectra with limiting magnitude down to V ≈ 19.5 mag (Luo et al., 2012). We take 37, 206 spectra as the initial dataset which are spectroscopically classified as ‘Galaxy’ by LAMOST 1D pipeline (Luo et al., 2015). In order to find E+A galaxies as many as possible, the low Signal–to–Noise Ratio(SNR) spectra are also remained. The detailed steps for searching E+A galaxies are described in the
2.2 Search method

In the searching procedure, the most obvious features: strong H\(\delta\), weak or no H\(\alpha\), [O ii], are considered as selection criteria. The final E+A galaxy sample is obtained after the strict identifications of following processes.

1. 162 spectra with redshift \(z > 1.18\) are removed since their H\(\delta\) lines are not within the spectral wavelength coverage of LAMOST.

2. The spectra are shifted to the rest wavelength frame, and the Equivalent Widths (EWs) of H\(\delta\), H\(\alpha\) and [O ii] lines are roughly measured in the wavelength window of 4082 — 4122 Å, 6553 — 6573 Å, and 3717 — 3737 Å (Goto, 2007a), respectively. If redshift \(z < 0.022\) where [O ii] double lines are not in the optical wavelength range of LAMOST, the EW\([\text{O II}]\) = 99; and if redshift \(z > 0.37\) where H\(\alpha\) line is not in this wavelength range, we set the EW\(H\alpha\) = 99 \(^1\).

3. Considering the uncertainty of EWs resulted from measurement errors, noise and estimation inaccuracy caused by using uniform wavelength windows for the various line widths of the spectra with lower SNR, our selection criteria for E+A galaxy candidates are temporarily relaxed by 0.5 Å than that used by Goto (2004). Therefore, the galaxies with EW\(H\delta\) > 3.5 Å, EW\(H\alpha\) > -3.5 Å and EW\([\text{O II}]\) > -3.5 Å will be identified in the next step.

4. The spectra satisfying the above conditions are visually inspected one by one in this step. Those spectra with specific redshift in which H\(\delta\), H\(\alpha\) are contaminated by sky lines or telluric lines are excluded. The spectra with redshift \(z \in [0.383, 0.445]\) are also removed from our sample since in this redshift range, H\(\delta\) lines of these spectra are just falling in the connection band of blue and red where the features might not be real because of low efficiency of the instrument in this range.

5. The wavelength window boundary of H\(\delta\), H\(\alpha\) and [O ii] are adjusted artificially to keep the completeness of lines. Then, equivalent widths of these three lines are remeasured inside the adjusted wavelength windows.

6. The final step of making these E+A galaxy sample is to remove the objects with EW\(H\delta\) < 4 Å, EW\(H\alpha\) < -3 Å and EW\([\text{O II}]\) < -2.5 Å, which are the same criteria as Goto (2007a) and 70 E+A galaxies are finally identified.

2.3 Catalog of 70 local E+A galaxies

Table 1 in Appendix lists the E+A galaxy sample selected from LAMOST DR2 by the method mentioned above, and Table 2 lists some corresponding photometric features. This first E+A galaxy sample
Fig. 1 Six spectral examples in our E+A galaxy sample are shown in this figure. In order to show the features clearly, these spectra are smoothed to $R \sim 1000$ by Gaussian function and shifted to rest wavelength frame. Some typical lines are marked by green dashed lines and the serial number of each object are marked in the bottom right corner.

of LAMOST survey includes 70 objects, in which 56 of them are newly discovered. These E+A galaxies span a redshift range of $0.0034 \leq z \leq 0.2541$.

In Table 1, each E+A galaxy is assigned a serial number (shown in column 1) that will be referred to throughout this paper and the signs marked upper right corner indicate that these objects have been published or studied in other literatures. The other columns show the basic information of these objects including designation, redshift, RA, DEC, $EW_{H\delta}$, $EW_{H\alpha}$, and $EW_{[O\ II]}$. The redshift, RA, and DEC are copied from LAMOST catalog, and equivalent widths of these lines are measured by the method mentioned in previous section. Fig. 1 shows six spectral examples of E+A galaxies, which are corresponding to the morphological classes in Fig. 6 as described in Section 3.3. Table 2 lists the magnitude of $u$, $g$, $r$, $i$ and $z$ bands, the colors of $g-r$, $r-i$, and image class by crossing these targets with available SDSS photometric catalog (discussed in the next section).

3 DISCUSSIONS

3.1 The distribution feature of the sample

Spatial distribution. The spatial distribution of E+A galaxies in our sample is shown in Fig. 2. Most objects locate in high galactic latitude areas, while only a few of them are in the direction of anti-galactic-center. This may not be the true distribution feature of E+A galaxies because of the selection effect of input catalog and relatively small size of our sample.

Redshift distribution. The redshift distribution of the E+A galaxies in our sample is shown in Fig. 3. The average redshift is 0.0875 and about 65.5% galaxies have the redshift $z < 0.1$. The main reason is that
This figure shows the spatial distribution of E+A galaxies selected from LAMOST DR2. These objects are marked by red circles in galactic coordinates.

of a peak at $z \sim 0.04$ as described as Goto (2005), since the aperture of LAMOST is so similar with that of SDSS that it will bring an aperture bias for the nearby E+A galaxies due to their large sizes. Nevertheless, these local E+A galaxies, especially for the large apparent size ones, are suitable for more sophisticated researches such as morphology studies, substructure studies, and IFU observations.

**Magnitude distribution.** Fig. 4 shows the magnitude distributions of E+A galaxies in our sample. The magnitude of g, r and i bands of these objects are obtained by crossing with SDSS photometric catalog. As seen in this figure, the magnitudes of g, r and i bands of most objects lie between 15 and 18 mag which is the good observational magnitude range of LAMOST. There are also some galaxies with both g and r bands fainter than 18 mag, however, they are too faint to resolve in the spectra because of their extremely low SNR.

**Fig. 3** The histogram of redshift distribution of the E+A galaxies in our sample. The redshift bin is 0.025.

**Fig. 4** The histogram of magnitudes distributions of E+A galaxies. The cyan, blue and yellow bars represent the magnitude distributions of g, r and i bands, respectively.
Fig. 5 The integrated age and metallicity contributions of all spectra in our sample estimated by ‘STARLIGHT’. The left panel is the age (15 ages: 0.001, 0.003, 0.005, 0.01, 0.025, 0.04, 0.1, 0.3, 0.65, 0.9, 1.4, 2.5, 5, 11 and 13 Gyr) contributions and the right panel is the metallicity (3 metallicities: Z = 0.004, 0.02 and 0.05) ones.

### 3.2 Stellar population synthesis

Stellar population synthesis are performed to each spectrum by using the stellar population synthesis code ‘STARLIGHT’ (Chen et al., 2010). During the estimation, we restrict the wavelength range as 3700 — 8500 Å (in rest frame), and choose 45 SSPs (Simple Stellar Populations, widely used in stellar population analysis) extracted from BC03 (Bruzual & Charlot, 2003) as templates. We use the Padova 1994 tracks, the Chabrier (2003) initial mass function, and the Calzetti et al. (1994) reddening law. To understand the contributions of different stellar populations to the whole sample, age and metallicity contributions of all objects are integrated as shown in Fig. 5.

The left panel of Fig. 5 indicates the obvious feature of young SPs with age of about 1 Gyr in the E+A galaxy spectra. Meanwhile, the old SPs with age of about 11 Gyr also contribute to these E+A galaxies. It confirms the selection criteria of E+A candidates properly. The right panel of Fig. 5 reveals that the metal–rich SPs have relatively higher contributions than metal–poor ones.

### 3.3 Image analysis

Many studies indicate that there are different features in bulge, halo and disk of such special galaxies. We have obtained the composite images of the E+A galaxies in our sample by crossing with SDSS photometric catalog. We divided these images into four classes as seen in Table 2 and Fig. 6.

1. Face–On–Small (FOS) are the E+A galaxies facing on to us and projected size < 3”.
2. Face–On–Large (FOL) are the ones facing on to us and projected size > 3”. For FOS and FOL E+A galaxies, FOS (FOL)1 indicates the galaxy has a very bright central bulge while FOS (FOL)2 has not.
3. Edge–On/Irregular(EOI) are the ones edging on to us or irregular galaxies.
Fig. 6 The examples of composite images of E+A galaxies. The corresponding spectra are shown in Fig. 1. The images are sorted by image classes shown in Table 2. The first column are FOL1 (upper panel, NO.70) and FOL2 (lower panel, NO.67), the second column are FOS1 (upper panel, NO.69) and FOS2 (lower panel, NO.25), the top right corner is EOI (NO.60), and the bottom right corner is SGs (NO.43).

4 SUMMARY

In this paper, we present a sample of E+A (post–starburst) galaxies based on the selection criteria $\text{EW}_{\text{H}\delta} > 4.0$ Å, $\text{EW}_{\text{H}\alpha} > -3.0$ Å and $\text{EW}_{\text{[O II]}} > -2.5$ Å , which was described in Goto (2004). At such a threshold, 70 E+A galaxies are identified from the LAMOST DR2. If we use a rigorous criteria of $\text{EW}_{\text{H}\delta} > 5.0$ Å, only 21 E+A galaxies remained which are specially marked in the Table 1. Meanwhile, we exclude dozens of galaxies with $3.0$ Å $< \text{EW}_{\text{H}\delta} < 4.0$ Å. These objects may be also important evolutionary stage of E+A galaxies especially for those with good signs of $\text{H}\alpha$ and $\text{[O II]}$ (i.e. they are absorption lines or extremely weak emission lines) in their spectra. In order to synchronize the selection criteria, we do not provide them in this paper.

A preliminary analysis for this sample is carried out, including parameter distribution features, stellar population synthesis, and image classification. This sample, together with available catalogs, can be used for statistical analyses and follow–up observations in various wavelengths.

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**APPENDIX : SAMPLE LIST**

Table 1: The E+A galaxies list of LAMOST DR2

| No. | Designation | Redshift | RA    | DEC    | EW_{[OII]} (Å) | EW_{Hδ} (Å) | EW_{Hα} (Å) |
|-----|-------------|----------|-------|--------|---------------|-------------|-------------|
| 1   | J111058.63+284038.2 | 0.030500 | 167.744297 | 28.677292 | 23.485 | 4.838 | 1.125 |
| 2   | J013936.64+294503.6 | 0.069828 | 24.902556 | 29.751000 | -2.159 | 4.458 | 0.580 |
| 3+  | J105606.79+022818.5 | 0.151924 | 164.028320 | 2.471810 | 4.661 | 6.268 | 0.398 |
| 4   | J040244.53+281231.0 | 0.049299 | 60.685553 | 28.203360 | -1.222 | 4.738 | 0.792 |
| 5*  | J111437.60+260726.2 | 0.073523 | 198.656698 | 26.123945 | -2.768 | 4.134 | 0.573 |
| 6   | J022949.96+031920.2 | 0.157351 | 37.479029 | 3.32285 | -0.690 | 4.098 | -0.840 |
| 7   | J023255.55+022333.5 | 0.174831 | 38.231477 | 2.542655 | -0.252 | 4.218 | 0.945 |
| 8** | J111742.26+042758.2 | 0.105046 | 169.426090 | 4.46180 | -3.667 | 14.348 | 1.095 |
| 9   | J023351.45+023320.2 | 0.137500 | 38.464377 | 2.555622 | -0.898 | 4.030 | 0.751 |
| 10  | J023255.55+022333.5 | 0.174794 | 38.231477 | 2.542655 | 0.139 | 4.040 | 1.095 |
| 11  | J104349.87+420923.3 | 0.234008 | 160.957814 | 42.156500 | 1.051 | 5.747 | 0.827 |
| 12* | J125006.26+452930.9 | 0.119162 | 192.526117 | 45.491935 | 1.876 | 4.303 | 0.809 |
| 13  | J121837.19+403252.0 | 0.130000 | 184.654973 | 40.547788 | 2.334 | 4.059 | 1.660 |
| 14  | J121711.03+411740.5 | 0.074864 | 184.295976 | 41.294593 | 3.128 | 4.851 | 1.149 |
| 15  | J233000.39+031347.6 | 0.058616 | 352.501629 | -3.296 | 4.487 | 1.058 |
| 16  | J233226.01+052135.7 | 0.069256 | 353.108400 | 5.359930 | 1.688 | 6.310 | 1.174 |
| 17  | J004025.91+052633.4 | 0.107554 | 10.107990 | 5.442630 | -1.545 | 6.142 | -0.325 |
| 18* | J004053.76+051154.5 | 0.135811 | 10.220400 | 5.354280 | 2.318 | 5.072 | 0.522 |
| 19  | J041626.24+312200.0 | 0.017100 | 41.067678 | 31.366692 | 2.629 | 4.733 | 1.259 |
| 20  | J013003.02+025652.5 | 0.215250 | 22.512591 | -2.947918 | 1.579 | 4.098 | 0.081 |
| 21  | J012804.46+012570.0 | 0.048006 | 22.018585 | -3.415584 | 5.687 | 4.333 | 1.672 |
| 22  | J023103.93+014148.1 | 0.021150 | 37.766400 | 1.696709 | 3.212 | 4.125 | 1.377 |
| 23  | J025648.87+052901.4 | 0.157710 | 34.203640 | 5.483740 | 2.007 | 4.031 | 0.469 |
| 24  | J230536.08+053345.4 | 0.051679 | 346.400360 | 5.562620 | 1.364 | 4.107 | 1.221 |
| 25* | J004025.91+052633.4 | 0.107554 | 10.107990 | 5.442630 | -2.691 | 6.142 | -0.325 |
| 26* | J004053.76+051154.5 | 0.135811 | 10.220400 | 5.354280 | 3.218 | 5.072 | 0.522 |
| 27  | J003409.66+084511.5 | 0.107989 | 8.540290 | 8.753200 | -0.021 | 4.276 | 0.865 |
| 28  | J001539.84+064101.0 | 0.069929 | 3.916040 | 6.683520 | 2.991 | 4.054 | 0.794 |
| 29  | J012730.22+003839.0 | 0.017848 | 21.342811 | -3.64178 | 3.737 | 4.020 | -0.604 |
| 30* | J001140.68+271111.2 | 0.157616 | 13.971952 | 27.686467 | -1.870 | 4.383 | 1.770 |
Table 1: – continued from previous page

| No. | Designation          | Redshift | RA (°) | DEC (°) | EW$_{OII}$ (Å) | EW$_{Hδ}$ (Å) | EW$_{Hα}$ (Å) |
|-----|----------------------|----------|--------|---------|---------------|--------------|--------------|
| 36  | J091000.34+274635.8  | 0.179827 | 137.50 | 27.77 | -0.948 | 4.003 | 0.534 |
| 37  | J012904.13004134.8   | 0.203008 | 22.27 | -3.69 | 0.371 | 4.236 | 0.400 |
| 38† | J012047.57003929.9    | 0.061524 | 20.19 | -3.66 | -0.445 | 6.026 | 0.984 |
| 39  | J012633.05003554.0    | 0.198778 | 21.63 | -3.92 | -0.494 | 4.296 | -1.417 |
| 40  | J012019.08003054.6    | 0.131500 | 19.78 | -3.89 | 0.203 | 4.780 | 0.875 |
| 41  | J094106.78+344356.7   | 0.049757 | 145.28 | 34.73 | 1.197 | 4.367 | 1.038 |
| 42  | J120329.26+023914.4   | 0.047823 | 180.87 | 2.65 | -1.550 | 4.284 | 0.645 |
| 43† | J120419.07001855.9    | 0.093631 | 181.08 | -0.32 | -0.991 | 6.486 | 1.193 |
| 44  | J091353.44+185630.4   | 0.032631 | 181.09 | 18.94 | 1.843 | 4.160 | 1.327 |
| 45† | J105755.26+334041.7   | 0.058130 | 164.48 | 33.68 | -2.467 | 5.174 | 1.455 |
| 46† | J104856.23+295406.7   | 0.197170 | 162.23 | 29.90 | -0.087 | 3.945 | 0.726 |
| 47  | J112844.18+234053.3   | 0.131520 | 172.18 | 23.68 | -0.897 | 4.966 | -0.026 |
| 48  | J113108.88+230325.7   | 0.031260 | 172.79 | 23.06 | 2.351 | 5.095 | 0.780 |
| 49† | J132318.78+130630.9   | 0.050370 | 200.82 | 13.10 | 0.631 | 3.570 | 1.005 |
| 50† | J112512.50+262646.5   | 0.047500 | 171.30 | 26.45 | 0.917 | 4.202 | 1.451 |
| 51  | J111728.76+275546.4   | 0.046750 | 169.37 | 27.92 | -0.709 | 4.009 | 1.073 |
| 52  | J112312.00+253841.8   | 0.022500 | 200.38 | 25.80 | -0.756 | 4.246 | 1.101 |
| 53  | J121351.59003052.1   | 0.080370 | 183.46 | 30.58 | -0.772 | 4.925 | 0.468 |
| 54  | J113108.88+230325.7   | 0.031260 | 172.79 | 23.06 | 2.351 | 5.095 | 0.780 |
| 55  | J111728.76+275546.4   | 0.046750 | 169.37 | 27.92 | -0.709 | 4.009 | 1.073 |
| 56  | J141127.49+243809.5   | 0.053631 | 181.52 | 24.63 | 1.024 | 4.986 | 1.383 |
| 57† | J142848.23+274149.6   | 0.109590 | 217.20 | 27.70 | 0.221 | 4.530 | 1.341 |
| 58† | J152426.50+080908.2   | 0.087130 | 231.11 | 8.16 | -1.267 | 4.842 | 0.960 |

Notes:
1. "No." is the serial number for every object and it will be referred to throughout this paper. The items of Designation, Redshift, RA and DEC are obtained from the catalogs of LAMOST DR2.
2. The '*' marked upper right corner of serial number indicates that these objects have been published or studied in other literatures.
3. The '+' marked upper right corner of serial number indicates that the EW$_{Hδ}$ > 5.0 Å.
Table 2: The photometric features of our E+A galaxy sample

| No. | Magnitude(mag) | g-r(dex) | r-i(dex) | Image Class |
|-----|---------------|----------|----------|-------------|
|     | u  | g  | r  | i  | z  |     |     |
| 1   | 17.78 | 15.93 | 15.13 | 14.70 | 14.36 | 0.8 | 0.43 | FOL1 |
| 2   | 18.84 | 17.04 | 16.32 | 15.97 | 15.71 | 0.72 | 0.35 | FOL1 |
| 3   | 21.01 | 18.95 | 17.78 | 17.35 | 17.02 | 1.17 | 0.43 | FOL2 |
| 4   | -   | -   | -   | -   | -   | -   | -   | -   |
| 5   | 17.62 | 15.79 | 15.04 | 14.71 | 14.46 | 0.75 | 0.33 | FOL1 |
| 6   | 20.17 | 18.47 | 17.39 | 16.95 | 16.60 | 1.08 | 0.44 | FOS2 |
| 7   | 19.73 | 17.93 | 17.03 | 16.65 | 16.41 | 0.9  | 0.38 | FOS1 |
| 8   | 18.43 | 16.52 | 15.50 | 15.08 | 14.70 | 1.02 | 0.42 | FOL2 |
| 9   | 19.73 | 17.93 | 17.03 | 16.65 | 16.41 | 0.9  | 0.38 | FOS1 |
| 10  | 19.72 | 17.95 | 17.09 | 16.69 | 16.39 | 0.86 | 0.4  | SGs  |
| 11  | 19.73 | 17.93 | 17.03 | 16.65 | 16.41 | 0.9  | 0.38 | FOS1 |
| 12  | 19.44 | 18.04 | 17.18 | 16.93 | 16.75 | 0.86 | 0.25 | SGs  |
| 13  | 19.04 | 17.21 | 16.44 | 16.12 | 15.83 | 0.77 | 0.32 | FOS2 |
| 14  | 19.03 | 17.31 | 16.36 | 15.97 | 15.61 | 0.95 | 0.39 | FOS2 |
| 15  | 20.10 | 18.31 | 17.39 | 17.02 | 16.71 | 0.92 | 0.37 | FOS2 |
| 16  | 18.58 | 16.79 | 16.04 | 15.68 | 15.41 | 0.75 | 0.36 | EOI  |
| 17  | 17.69 | 16.02 | 15.33 | 15.02 | 14.80 | 0.69 | 0.31 | FOL1 |
| 18  | 19.59 | 17.64 | 16.76 | 16.34 | 16.02 | 0.88 | 0.42 | FOS2 |
| 19  | 17.48 | 15.61 | 14.71 | 14.24 | 13.89 | 0.9  | 0.47 | FOL1 |
| 20  | 20.65 | 18.64 | 17.64 | 17.30 | 17.07 | 1    | 0.34 | FOS2 |
| 21  | 18.89 | 17.19 | 16.43 | 16.09 | 15.80 | 0.76 | 0.34 | EOI  |
| 22  | 17.86 | 16.34 | 15.72 | 15.41 | 15.18 | 0.62 | 0.31 | FOS2 |
| 23  | 20.30 | 18.40 | 17.34 | 16.88 | 16.55 | 1.06 | 0.46 | FOS2 |
| 24  | 18.76 | 17.06 | 16.34 | 16.00 | 15.75 | 0.72 | 0.34 | EOI  |
| 25  | 20.32 | 18.34 | 17.32 | 16.88 | 16.55 | 1.02 | 0.44 | FOS2 |
| 26  | 19.30 | 17.48 | 16.64 | 16.28 | 15.99 | 0.84 | 0.36 | FOS2 |
| 27  | 19.55 | 17.31 | 16.26 | 15.77 | 15.38 | 1.05 | 0.49 | FOS2 |
| 28  | 18.83 | 17.20 | 16.53 | 16.21 | 15.95 | 0.67 | 0.32 | SGs  |
| 29  | 18.90 | 17.39 | 16.67 | 16.32 | 16.09 | 0.72 | 0.35 | FOS2 |
| 30  | 18.25 | 16.63 | 15.94 | 15.58 | 15.32 | 0.69 | 0.36 | FOS2 |
| 31  | -   | -   | -   | -   | -   | -   | -   | -   |
| 32  | -   | -   | -   | -   | -   | -   | -   | -   |
| 33  | 19.49 | 17.96 | 17.27 | 16.98 | 16.84 | 0.69 | 0.29 | FOS1 |
| 34  | 18.49 | 16.96 | 16.24 | 15.90 | 15.63 | 0.72 | 0.34 | FOS2 |
| 35  | 18.91 | 17.13 | 16.54 | 16.22 | 15.98 | 0.59 | 0.32 | FOS2 |
| 36  | 20.16 | 18.26 | 17.32 | 16.89 | 16.61 | 0.94 | 0.43 | SGs  |
| 37  | 20.63 | 18.99 | 17.85 | 17.33 | 16.99 | 1.14 | 0.52 | FOS2 |
| 38  | 21.19 | 19.12 | 18.18 | 17.77 | 17.44 | 0.94 | 0.41 | FOS2 |
| 39  | 20.09 | 18.56 | 17.72 | 17.37 | 17.09 | 0.84 | 0.35 | FOS2 |
| 40  | 18.97 | 17.42 | 16.74 | 16.42 | 16.17 | 0.68 | 0.32 | FOS1 |
| 41  | 18.60 | 17.04 | 16.49 | 16.24 | 16.07 | 0.55 | 0.25 | FOS2 |
| 42  | 19.16 | 17.54 | 16.86 | 16.55 | 16.30 | 0.68 | 0.31 | EOI  |
| 43  | 17.59 | 16.08 | 15.61 | 15.45 | 15.24 | 0.47 | 0.16 | SGs  |

Continued on next page
Table 2: – continued from previous page

| No. | u (mag) | g (mag) | r (mag) | i (mag) | z (mag) | g-r (dex) | r-i (dex) | Image Class |
|-----|---------|---------|---------|---------|---------|-----------|-----------|-------------|
| 44  | 17.07   | 15.41   | 14.79   | 14.48   | 14.26   | 0.62      | 0.31      | FOL1        |
| 45  | 19.22   | 17.44   | 16.80   | 16.47   | 16.24   | 0.64      | 0.33      | FOS2        |
| 46  | 19.49   | 17.71   | 17.09   | 16.78   | 16.57   | 0.62      | 0.31      | FOS2        |
| 47  | 20.28   | 18.60   | 17.65   | 17.30   | 17.06   | 0.95      | 0.35      | FOS2        |
| 48  | 18.40   | 16.77   | 16.13   | 15.84   | 15.61   | 0.64      | 0.29      | FOS1        |
| 49  | 19.00   | 17.21   | 16.38   | 15.97   | 15.62   | 0.83      | 0.41      | SGs         |
| 50  | 16.95   | 15.25   | 14.48   | 14.10   | 13.83   | 0.77      | 0.38      | FOL2        |
| 51  | 19.05   | 17.41   | 16.70   | 16.36   | 16.13   | 0.71      | 0.34      | FOS2        |
| 52  | 18.34   | 16.79   | 16.16   | 15.89   | 15.66   | 0.63      | 0.27      | FOL1        |
| 53  | 19.11   | 17.35   | 16.58   | 16.21   | 15.93   | 0.77      | 0.37      | FOS2        |
| 54  | 19.77   | 18.50   | 17.51   | 17.07   | 16.83   | 0.99      | 0.44      | FOS2        |
| 55  | 18.40   | 16.97   | 16.46   | 16.20   | 16.00   | 0.51      | 0.26      | FOS2        |
| 56  | 20.15   | 18.42   | 17.61   | 17.27   | 16.99   | 0.81      | 0.34      | FOS2        |
| 57  | 17.54   | 16.13   | 15.66   | 15.42   | 15.26   | 0.47      | 0.24      | SGs         |
| 58  | 19.16   | 17.53   | 16.86   | 16.60   | 16.36   | 0.67      | 0.26      | FOS1        |
| 59  | 19.63   | 18.06   | 17.43   | 17.12   | 16.90   | 0.63      | 0.31      | FOL2        |
| 60  | 16.63   | 15.85   | 15.69   | 15.59   | 15.52   | 0.16      | 0.1       | EOI         |
| 61  | 18.99   | 17.25   | 16.47   | 16.15   | 15.86   | 0.78      | 0.32      | FOS2        |
| 62  | 17.91   | 16.63   | 16.21   | 16.00   | 15.82   | 0.42      | 0.21      | FOL1        |
| 63  | 19.24   | 17.46   | 16.68   | 16.35   | 16.07   | 0.78      | 0.33      | FOS2        |
| 64  | 19.09   | 17.45   | 16.82   | 16.59   | 16.39   | 0.63      | 0.23      | FOL1        |
| 65  | 18.47   | 17.26   | 16.99   | 16.85   | 16.84   | 0.27      | 0.14      | SGs         |
| 66  | 17.55   | 16.06   | 15.48   | 15.20   | 14.99   | 0.58      | 0.28      | FOL2        |
| 67  | 17.55   | 16.03   | 15.50   | 15.25   | 15.06   | 0.53      | 0.25      | FOL2        |
| 68  | 18.21   | 16.56   | 15.91   | 15.61   | 15.39   | 0.65      | 0.3       | FOL1        |
| 69  | 19.66   | 17.98   | 17.35   | 17.05   | 16.83   | 0.63      | 0.3       | FOS1        |
| 70  | 17.31   | 15.86   | 15.30   | 15.02   | 14.81   | 0.56      | 0.28      | FOL1        |

**Notes:**
1. ‘No.’ is the serial number for every object and it will be referred to throughout this paper. The magnitudes of u, g, r, i, z, and color of g-r and r-i are obtained from the photometric catalog of SDSS.
2. We assign ‘-’ for three objects with no photometric information in SDSS catalog.
3. The Image Class is visually assigned for each object based on the Section 3.3.

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