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Catalog of edge-on galaxies using the Pan-STARRS1 survey data

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We have created a catalog of edge-on galaxies based on the publicly available DR2 data from the Pan-STARRS survey. The intensive use of an artificial neural network has significantly improved the quality of candidate selection. The catalog provides homogeneous information on astrometry, photometry, and non-parametric morphological statistics for 16551 edge-on galaxies. Our catalog is intended for studying the three-dimensional structure of galaxies with different morphologies and the scaling relations for disks and bulges.

Keywords: astronomical data bases, catalogues, galaxy statistics, galaxy photometry

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1. Introduction

The knowledge and information of the three-dimensional distribution of matter is extremely important to understand the dynamics and evolution of galaxies. Unfortunately, in extragalactic astronomy, projection effects obscure the “depth” of objects. As a result, we know the radial distribution of light in galaxies very well, but the vertical distribution of matter in the disks has been explored for only a small number of edge-on galaxies.

Only few catalogs are dedicated to edge-on galaxies. The updated version of the classic Flat Galaxies Catalogue [1], the Revised Flat Galaxy Catalogue (RFGC, [2]) contains 4236 thin spiral galaxies. These flat galaxies were selected during a systematic visual inspection of all blue end red prints of the Palomar Observatory Sky Survey (POSS-I) and the ESO/SERC sky survey. Using the modern Sloan Digital Sky Survey (SDSS), [3, 4] identified a number of edge-on galaxies, which were automatically classified into various Hubble types. Finally, the catalog of genuine edge-on disk galaxies (EGIS, [5]) containing 5747 objects was generated by automatic candidate selection from SDSS DR7 and their subsequent visual inspection.

Here we introduce a new catalog of 16551 Edge-on Galaxies found In the Pan-STARRS survey (EGIPS).

2. Candidate selection

We searched for edge-on galaxies using the public archive of the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS, [6]) survey. The survey covers three quarters of the sky down to $\delta = -30^0$ in five (g, r, i, z, y) broadband filters using the 1.8-meter telescope of the Haleakala Observatory (Hawaii, USA).

For accurate selection of candidates, we took advantage of the Artificial Neural Network (ANN) technology using the TENSORFLOW[a] package. The convolutional neural network (CNN) is commonly used to classify images. Our CNN was trained on a sample of 5747 edge-on galaxies from the EGIS catalog [5] in the three g, r, i bands. The final formal classification accuracy is better than 99%. The comparison with an independent sample of RFGC [2] galaxies showed that only 20 out of 3027 galaxies were misclassified. This translates into an error rate better than 1%.

A typical candidate search consists of detecting objects in a r-band image using the `detect_source` function of the PHOTUTILS library [7]. Then the object image is cropped out of the full frame and scaled to 48×48 pixels. The stacked array of the g, r and i images is fed to our neural network. We consider an object as a good candidate for an edge-on galaxy if at least three of our five CNN models give a better than 0.5 probability for the edge-on class. Finally, after processing all $\sim 200{,}000$ Pan-STARRS skycell fields, we selected 26719 candidates.

All candidates were visually inspected by a dozen professional astronomers to eliminate asterisms, image defects, misclassifications, as well as non-edge-on galaxies. To reduce subjectivity, each object was independently examined by at least three different people.

Finally, the catalogue contains 16551 objects. To date, it is the largest sample of edge-on galaxies. The public access to the EGIPS catalogue is supported by the Edge-on Galaxy Database[b] [8].

3. Photometry and non-parametric morphology

As part of the work on the catalog, we performed SEXTRACTOR [9] photometry and non-parametric morphology estimation using the STATMORPH [10] package. Comparison of our Petrosian magnitudes obtained using Pan-STARRS1 survey data with independent aperture photometry based on SDSS images [5] shows excellent agreement, illustrated in Fig. 1. The scatter is

[a] https://www.tensorflow.org/
[b] https://www.sao.ru/edgeon/

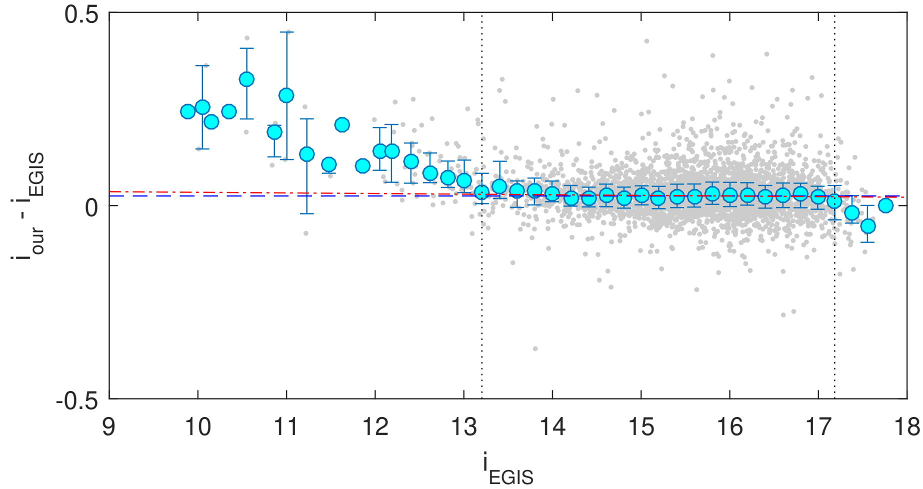

Figure 1: The difference between our Petrosian and EGIS aperture magnitudes in the i band is shown by gray dots. The running median with a 0.2 mag window and corresponding 25 and 75% quartiles are indicated by cyan dots with error bars. The black dotted vertical lines represent the accordance range. The red dash-dotted line is a robust linear fitting inside the accordance range. The blue dashed line corresponds to the median difference between the photometries.

less than 0.05 mag in the r and i bands and about 0.07 mag in the g band, despite the difference between the Pan-STARRS and SDSS photometric systems, and the difference in the photometry methodologies used. For the big galaxies brighter than $i \approx 13.2$ mag the total flux is systematically underestimated due to the specifics of the sky subtraction procedure in Pan-STARRS.

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