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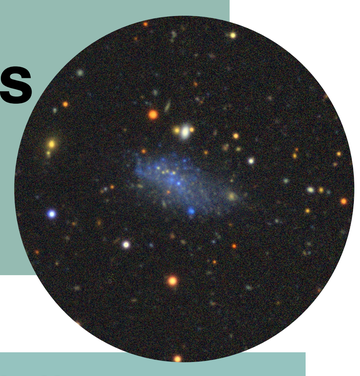
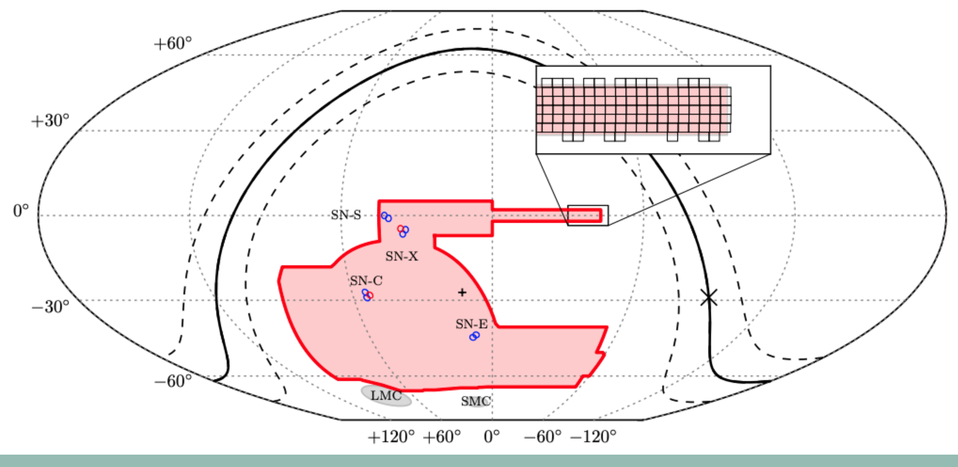
Exploring the Dark Side: Uncovering low-surface brightness galaxies in DES Y6



Low-surface brightness galaxies (LSBGs) are unique systems that are generally defined by being fainter than the ambient night sky (*Disney et al. 1976*). These systems represent galaxies with extremely low stellar densities, being mostly dominated by their dark matter halo. It has been theorized that LSBGs form naturally within ΛCDM, but more work must be done to make these comparisons (*Amorisco and Loeb, 2016*). Using the Y6 Gold catalogue from the Dark Energy Survey (DES), we plan to assemble a catalogue of LSBGs to compare theory to observation.

The Data

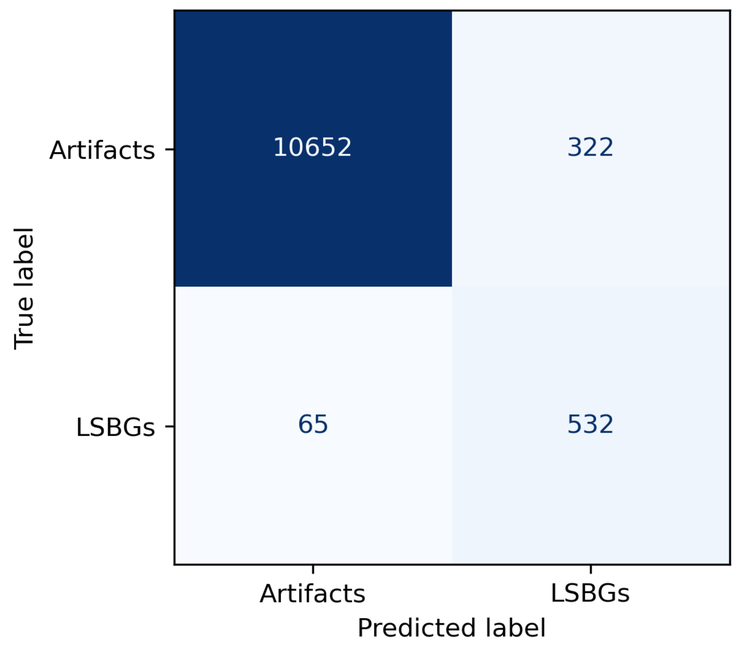
The Dark Energy Survey is a survey covering 5,000 deg^2 of the southern hemisphere (**DES Y6:** *Abbott et al., 2021*). DES provides extremely deep data, perfectly well-suited to search for these objects lying at the detection limits of our surveys. DES utilizes the 4m Blanco telescope at Cerro Tololo Inter-American Observatory. In a previous study carried out by Tanoglidis et al., they found ~23,000 LSBGs within the first three years of the survey.



Our Classifier

For this search, we trained a Random Forest Classifier (RFC) to identify LSBGs withing the Y6 Gold catalog. To train the RFC, we utilized the Y3 catalog, objects from visually inspected regions within the DES footprint, and LSBGs detected in the SMUDGes survey (**SMUDGes:** Zaritsky, et al. 2019).

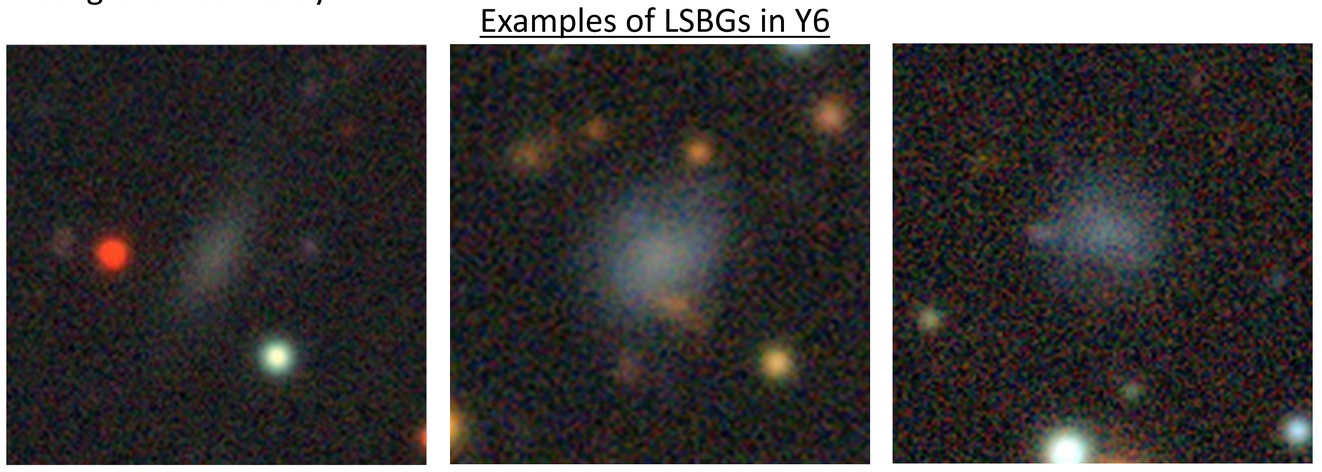
Throughout the process, we focused on balancing the completeness and purity of the classifier and did so by changing the number of LSBGs and artifacts within the training sample. Once deciding on a training sample, we divided it into three subsamples, where the classifier would be trained on one subsample, we would obtain a confusion matrix with another, and the last subsample would be used to validate the metrics we obtained. Having finalized and validating our training sample, we then proceeded to obtain a confusion matrix for our classifier (*see below).* After running the classifier on the Y6 Gold catalog, we identified 82,698 potential LSBGs within the data.



Visual Inspection and Sersić Modelling

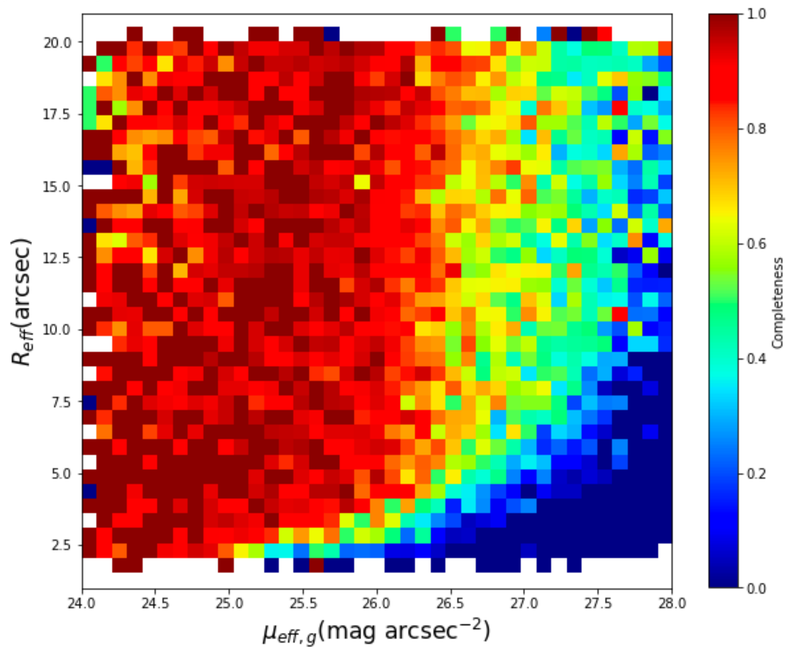
We organized a visual inspection campaign over the course of a couple months to search through the RFC's output. We removed ~30,000 false detections and began the process of fitting Sersić profiles to these systems using Galfit (*Peng, et al., 2010*). In order to properly fit these objects, we must go through a tedious process of fixing "shredded" systems and masking contaminating sources in the images. We have finished identifying LSBGs that need their models fixed and are in the process of fixing them currently.

Examples of LSBGs in Y6



Completeness and Future Work

To compare our sample of LSBGs to simulations, we must understand how complete our sample is. We have utilized artificial dwarf injections to characterize the completeness of our classifier in size-surface brightness space. Based on our current sensitivity plots, we are most complete with objects brighter than 26.5 mag arcsec^{-2} which is comparable to the completeness of other surveys such as LIGHTS (**LIGHTS:** *Zaritsky et al., 2024*).



To characterize the completeness, we look at how many dwarf galaxies are recovered in each bin of size (y- axis) and surface brightness (x-axis).

While a majority of our work is similar to past LSBG searches, the novel aspect will be including a comparison from observation to theory. We've found that all of the Y3 LSBGs have been recovered by our classifier, and plan to identify overlapping objects with other surveys once our sample is finalized.

Local Volume Dwarf Galaxies

In these LSBG searches, we often find dwarf galaxies that lie in the Local Volume. In addition to recovering known systems such as the Fornax and Sculptor dwarf systems, we have also recovered several new dwarf galaxies that appear to be semi-resolved indicating that they may lie in the Local Volume. We have obtained follow up observations to obtain distances for a few of them, and plan to utilize high-resolution observations to understand where they lie in the Local Volume.

The search for LSBGs in DES Y6 will provide us with a catalog of LSBGs within the footprint that can be used to make comparisons to cosmological simulations. We have trained and validated the performance of our RFC and are currently fitting Sersić profiles to our LSBGs. We have also made great strides in identifying new dwarf systems lying within the Local Volume.

STAY TUNED FOR OUR RESULTS !