Illuminating Low Surface Brightness Objects with JWST

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Introduction

Low surface brightness galaxies (LSBs) are dimmer than the night sky, and have been historically difficult to detect. Most observational studies of LSBs thus far have been focused on the local universe, due to detection limits. With the launch of the James Webb Space Telescope (JWST), we can see objects at greater depths than past observational surveys. This project aims to detect and study LSBs past the local universe, and search for explanations as to why they evolve to be low surface brightness.

Data/Catalog

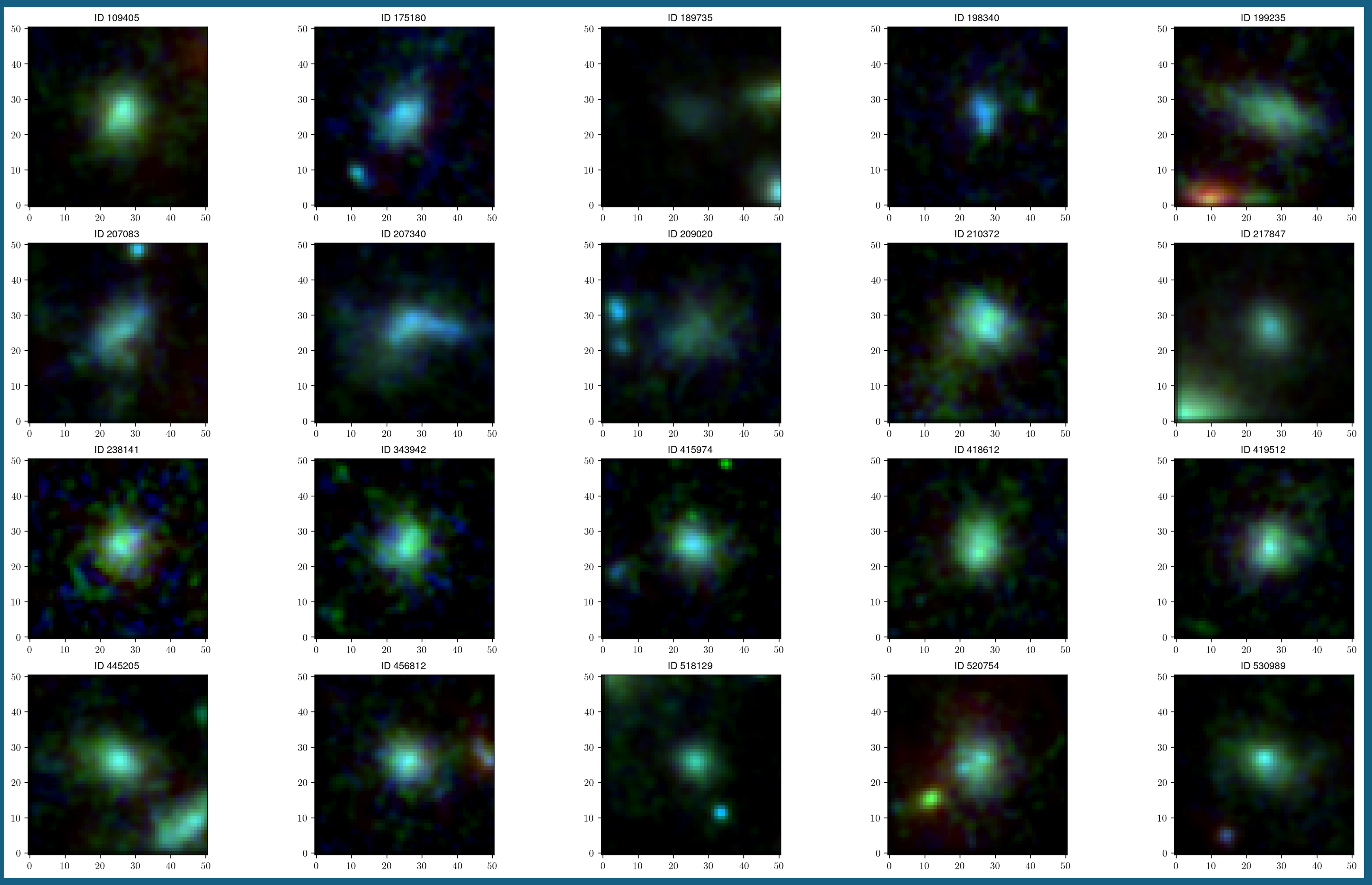
This study was taken with data from the James Webb Space Telescope (JWST) Advanced Deep Extragalactic Survey (JADES; PIs Rieke and Lützgendorf; Eisenstein et al. 2023), which is a collaboration between the Near-Infrared Camera (NIRCam) and Near-Infrared Spectrograph (NIRSpec) science teams. The photometric catalog used is described in Rieke et al. (2023).

Selection Process

Starting with all of the objects in our photometric catalog, we used the following steps to select our LSBs:

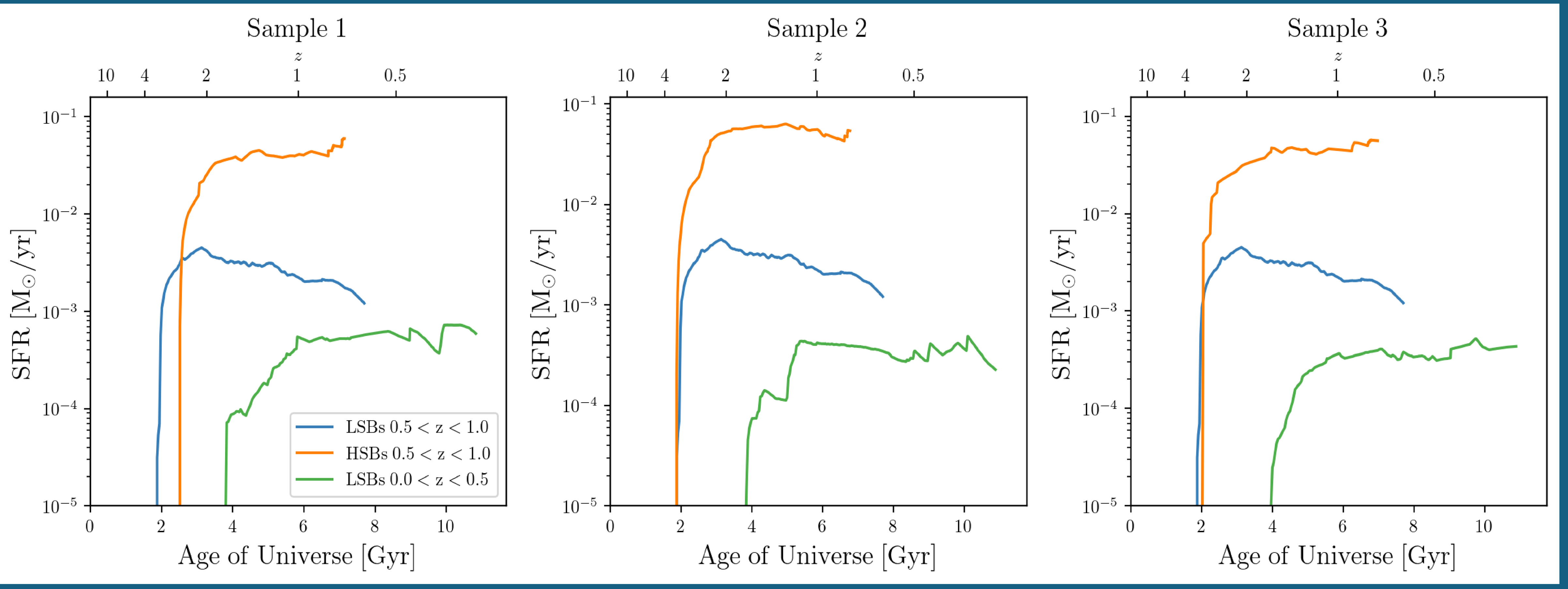
1. *Redshift range.* Using a redshift catalog from Hainline et al. (2024), we consider objects between $0.5 < z < 1.0$
2. *Signal-to-noise*. Using the measured fluxes and errors from the catalog, we cut objects with a signal-to-noise ratio less than 10 in the F200W filter
3. *Measuring surface brightness*. We use a Python program *pyimfit* to measure surface brightness from the mosaic image in F200W, and keep objects that have an average surface brightness dimmer than 24 mag arcsec^2
4. *Visual inspection.* To avoid letting false sources (diffraction spikes, tidal tails, etc.) we visually look at the objects in the mosaic image to make sure they are actual faint galaxies

After these steps, we are left with 38 high-redshift LSBs in our sample.



Above: False-color RGBs of the 20 largest LSBs in our sample. Each cutout is 50 pixels by 50 pixels, or 1.5x1.5 arcseconds. Uses F356W, F200W, and F115W for the R, G, and B filters, respectively.

Below: Median star formation histories (star formation rate over time) for our high redshift LSBs (blue), three random samples of local LSBs (green), and three random samples of HSBs (orange).



Analysis With BAGPIPES

- We can run a Python program called BAGPIPES on the observational data of an object to get star formation histories and other useful quantities
- In addition to running BAGPIPES on our 38 high redshift LSBs, we pick three random samples of 40 HSBs (average surface brightness) and three random samples of 40 local LSBs ($z < 0.5$)
- We can make many graphs comparing these different samples, but the most insightful is the star formation history, shown below
- BAGPIPES works by using the object's spectral energy distribution (SED) from the observational data, and matching it to stellar population models
- Our results from BAGPIPES so far indicate that these LSBs are very old objects, with reduced star formation and stellar mass when compared with the HSBs
- LSBs and HSBs start star formation around the same time, but something happens that quenches the star formation rate of the LSBs

Conclusions

- Analysis with the results from BAGPIPES is ongoing, as we are in the process of reviewing how our observations could support previous theories and models of LSBs
- LSBs show quenched star formation throughout their lifetime, leading to lower stellar mass and dimmer surface brightness
- As of now, we have not ruled out dust as a factor in the surface brightness of these objects
- LSBs and HSBs seem to have similar origin, but very different evolution throughout their histories

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