Low-Surface-Brightness Features in Polar-Structure Galaxiess

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Abstract

Polar-structure galaxies (PSGs) have similar formation mechanisms as **low-surface-brightness (LSB)** features and thus make good candidates for LSB analysis. LSB features from the **COUGS-DESI** catalog of 2,989 PSGs from the **DESI Legacy Imaging Surveys DR10** were identified in 725 galaxies whose PSG type fell into either polar rings (PRs), polar halos (PHs), polar bulges (PBs), or polar dust lanes (PDLs), and these features were measured for 394 of these galaxies. We identify that LSB features are 49% more likely to appear in PSGs than galaxies lacking a **polar structure (PS)**. We additionally find high correlation between many features, and observed an increasing feature rate by mass, but not monotonically as suggested in literature.

Background & Motivation

A PSG is a special type of galaxy that has an outer structure of gas and stars (the PS) that is arranged orthogonally to the major axis of the "**host galaxy**". They make good candidates for research because of the differences in the PS and the host and because they are formed in many of the same ways that LSB features—dim features that are a result of interactions between a galaxy and its environment—form. There are several different types of LSB features, and each one gives insight into the formation history of a given galaxy. LSB features include **tidal tails** and **streams**, **plumes**, **arcs**, **bridges**, **shells**, **ripples**, **tidally distorted satellite debris**, and **fans**. The main goal of this research was to create a classification table of PSGs with LSB features, classifying those features and measuring their **surface brightness (SB)** statistics and size, and to build a better understanding of formation mechanisms.

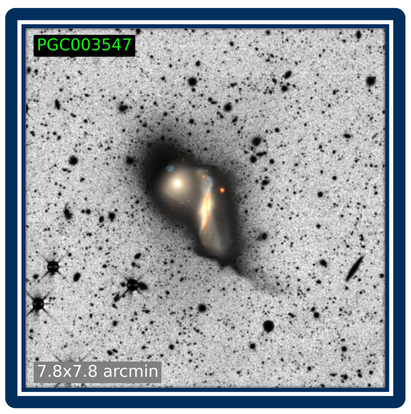

Fig. 1: A PSG with LSB features.

Methodology

- All galaxy images were taken from the COUGS-DESI catalog.
- Enhanced images (Fig. 1) were created to better identify LSB features, involving mainly inverting pixels and adding an RGB overlay.
- For selection only, the *g*, *r*, *i*, and *z* bands are combined to increase signal-to-noise ratio.
- Noise is identified using NoiseChisel and masked out; a SB mask is also applied to only select signal in the relevant SB range.
- Foreground objects are masked out to avoid interference with measurements.
- LSB features are extracted and classified (Fig. 2).

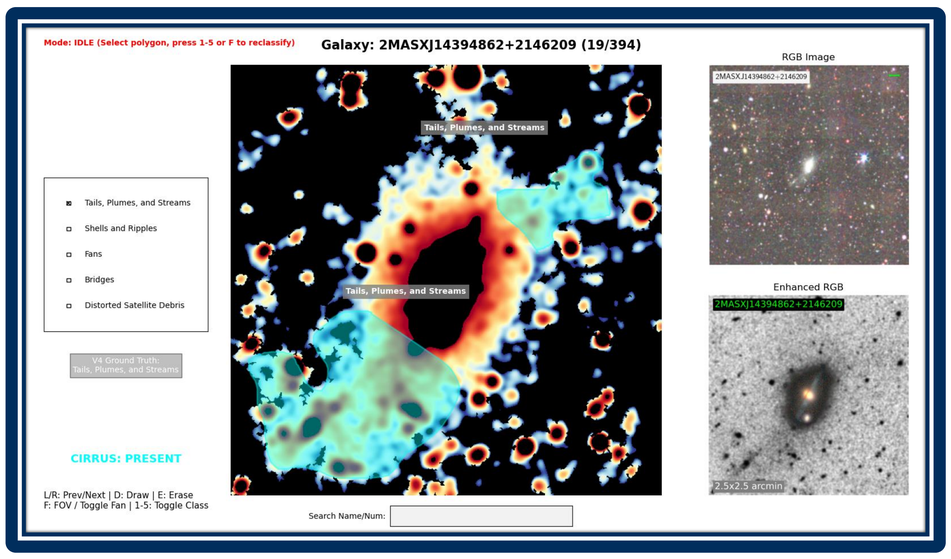

Fig. 2. The interface for LSB analysis. The central image is an SB heatmap.

Results, Conclusion, & Future Work

We find, using the Fisher-Irwin test, that LSB features are significantly more likely to occur (by 49%) in PSGs than in non-PSG galaxies. Many of the features are correlated with each other, helping to indicate which formation mechanisms are dominant for which features. We additionally find that the feature frequency does not increase monotonically as suggested in previous literature, but rather, it peaks at a certain mass. Future work could involve investigating the formation mechanisms by further constraining their possibilities for each LSB feature type, as well as measuring LSB features in simulations to provide constraints on simulation parameters.

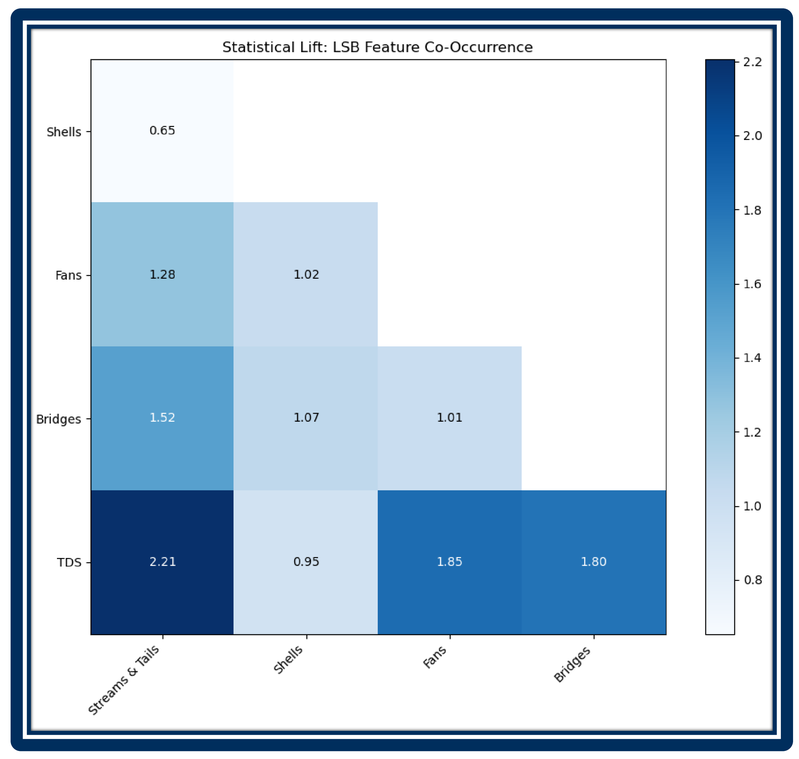

Fig. 3. Correlation between features.

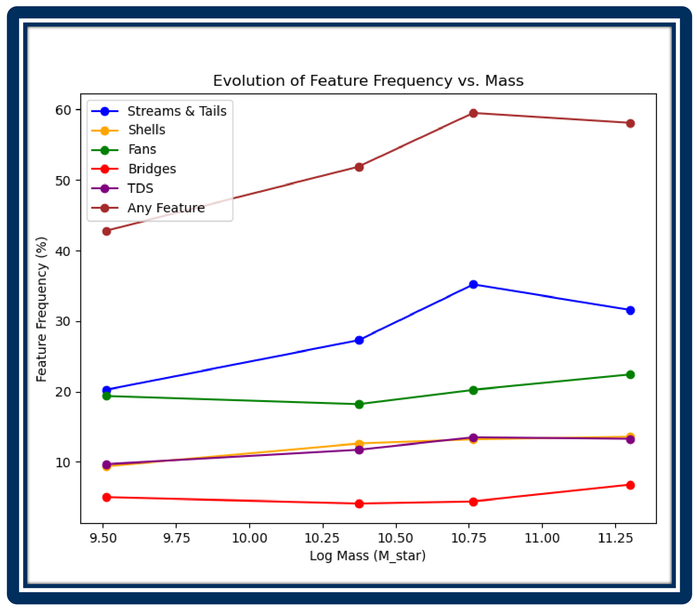

Fig. 4. Mass evolution by LSB feature type.

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