Characterizing the Low Surface Brightness structures of galaxies in the DESI Legacy Imaging Survey

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Abstract The influence of assembly history on galaxy formation could be constrained by trends in stellar halo properties with galactic observables (such as the total galaxy mass, color or gas fraction). Our goal is to develop the uniform, automated measurements of bulk stellar halo properties that are easy to apply to large datasets and to compare with models. As a first step, we have analyzed the diffuse light around 36 Milky Way-like galaxies from the Satellites Around Galactic Analogs Survey (SAGA) (Mao, et al. 2021) using images from the Dark Energy Spectroscopic Instrument Legacy Imaging Survey (DESI-LS) (Cooper, et al. 2023). In this poster we describe our sample, the DESI-LS data and the basis of the methods we are developing. In future, we will apply these methods to much large numbers of galaxies in DESI-LS to study large-scale trends of stellar halo properties.

Stellar halo

- **Understanding the formation and evolution of galaxies**:
  The stellar halo is a diffuse, roughly spherical component of a galaxy consisting of low surface brightness (LSB) stellar structures which including stellar shells, tidal streams and tidal tails formed during major mergers. The properties of halo stars can offer valuable insights into the formation and evolution of the galaxy.
- **Exploring the properties of dark matter:**
  As the universe evolves, smaller structures merge to form larger ones. During this process, the stars from the dwarf galaxies contribute to the stellar halo of the galaxy like Milky Way. Moreover, the structures and kinematics of the stellar halo can be used to probe the gravitational potential of the dark matter halo.

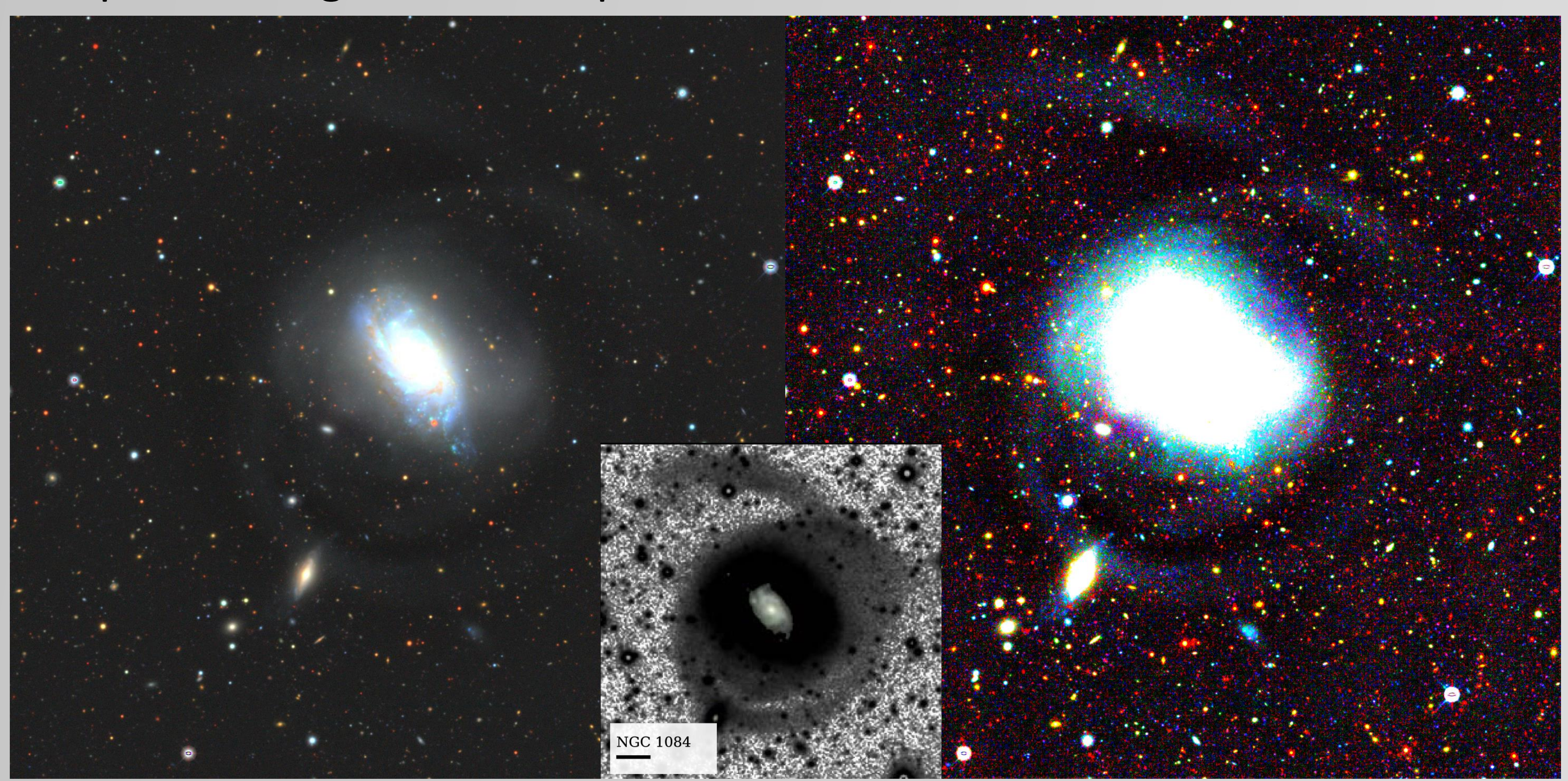

Fig. 1: *The left panel is the g-,r-,z- stack image of NGC1084 from DESI-LS, and the right panel is the image after adjusting the contrast and saturation, from which we can faintly see the existence of stellar halo and tidal streams. In addition, the structures can be seen more clearly in the small panel* (Merritt, et al. 2016), *especially the diffuse, roughly spherical stellar halo surrounding the host galaxy.*

Motivation

Most previous work on images of extragalactic stellar halos has focused on identifying and classifying individual LSB features (e.g. Sola et al, 2022). We are more interested in understanding the overall statistical properties of the entire stellar halo, rather than the individual LSB structures. To achieve this, we are exploring a different approach: **our goal is to develop uniform, automated measurements of bulk stellar halo properties that are easier to apply to large datasets and to compare with models.**

Ongoing and future work

- Now we are improving the masking method, trying to mask the background starlight without masking the structures in the stellar halo. We also need a more rigorous method to define the range of radius that we are associate with the stellar halo.
- In the future, we will apply these methods to much large numbers of galaxies in DESI-LS to study large-scale trends of stellar halo properties.

References

[1] Sola, E., et al. 2022, A&A, 662A, 124S
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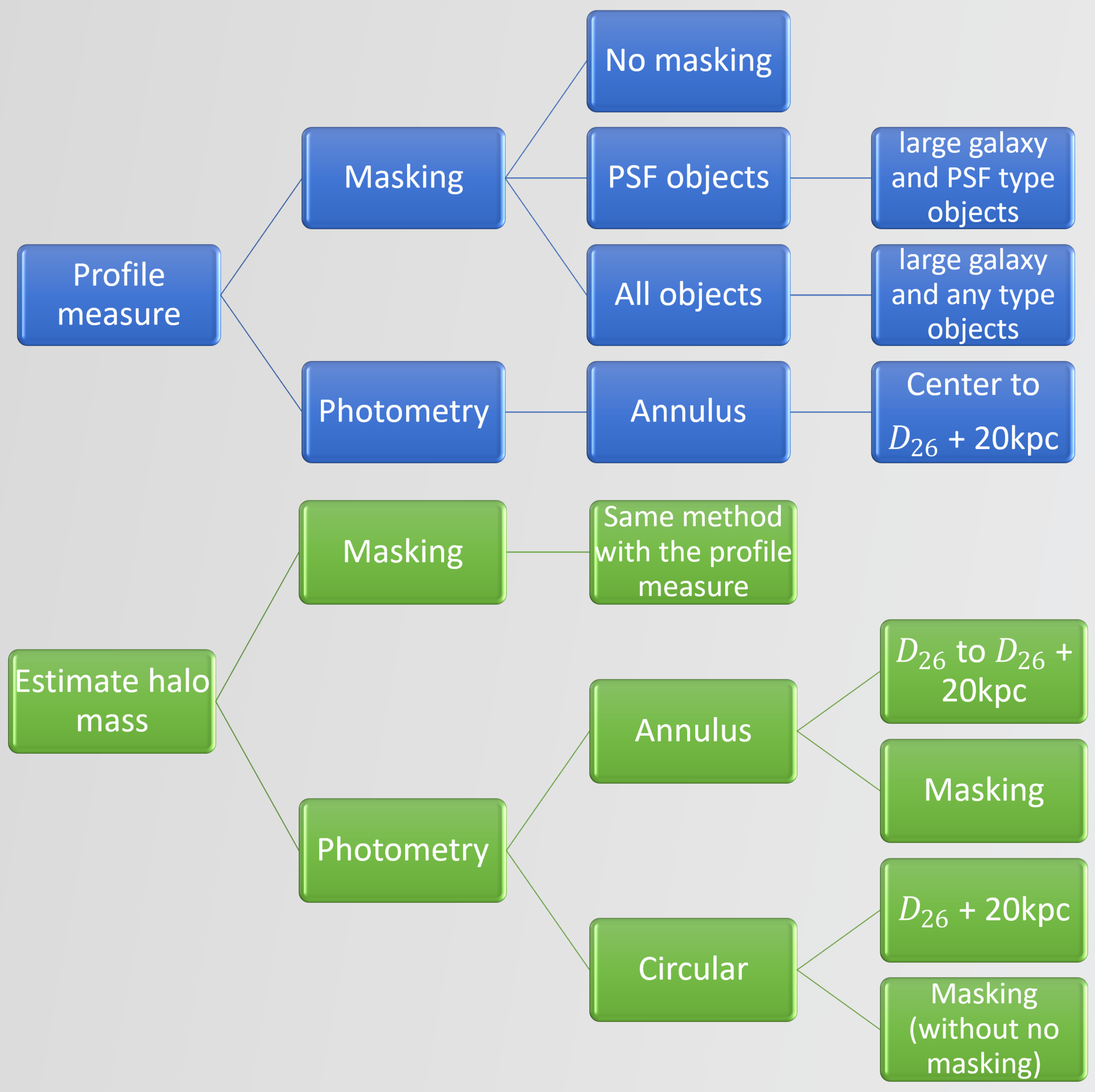
[3] Cooper, A. P., et al. 2010, MNRAS, 406, 744C
[4] Gómez, F. A., et al. 2013, MNRAS, 436, 3602G
[5] Cooper, A. P., et al. 2023, ApJ, 947, 37C
[6] Mao, Y-Y., et al. 2021, ApJ, 907, 85M

Photometry method



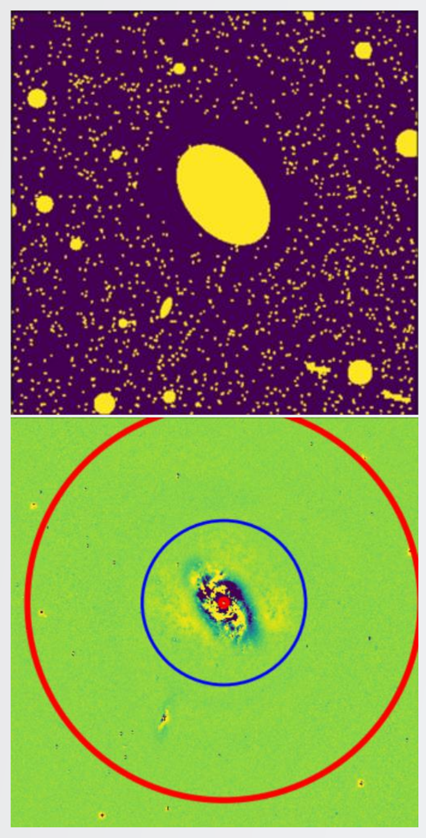


Fig. 3: *The upper panel shows the masking image applied to the photometry. The lower panel shows the photometric range, where the blue circle is the galaxy radius* (D_{26}).

Fig. 2: *The blue dendrogram is the method we are exploring to measure the profile of galaxies and their stellar halos. The masking method show on picture (both contain the large-scale galaxy masking provided by the SGA catalog). The green dendrogram is the method we try to estimate the stellar halo mass (luminosity). The photometry method is divided into two types: annulus photometry and circular photometry.*

Result

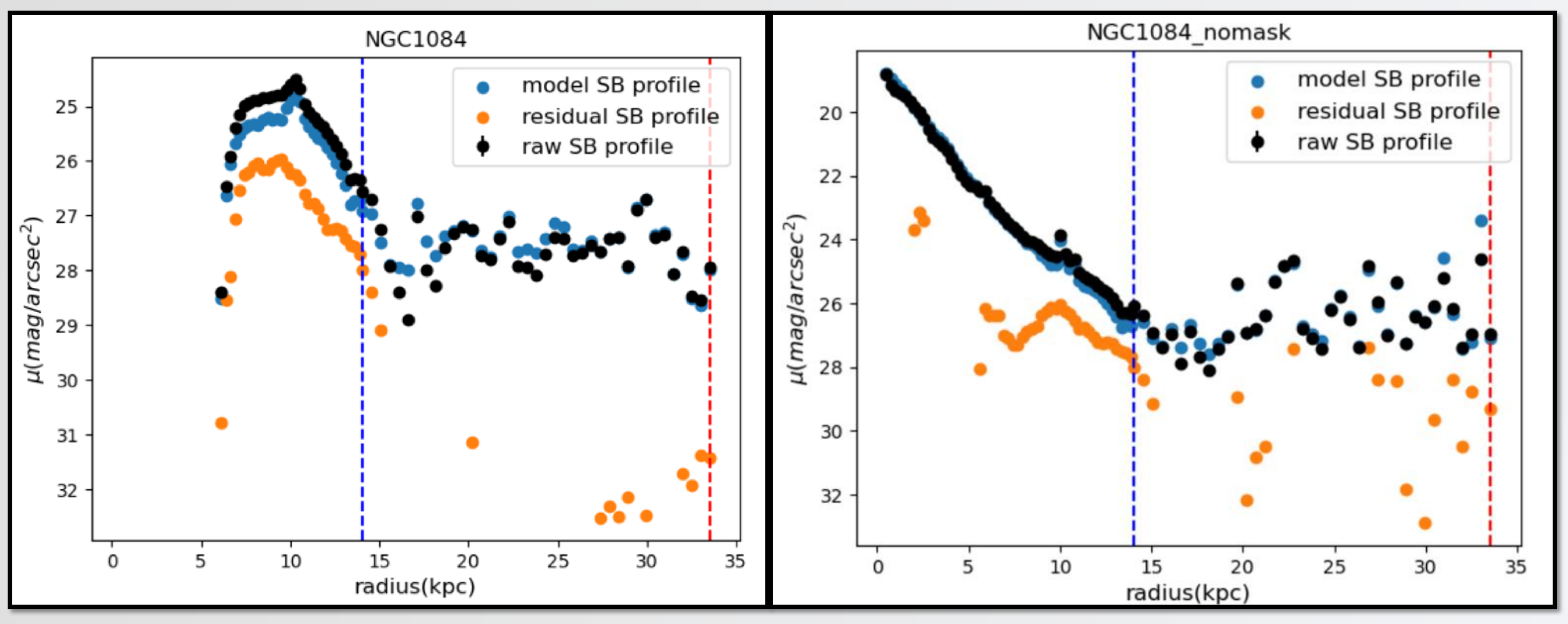


Fig. 4: *The left panel is the surface brightness profile obtained with PSF masking of NGC1084. The right panel is the profile without masking. We do the photometry to the raw, model (from DESI-LS) and the residual (raw - model) image respectively. The blue dash line represents the radius of the host galaxy* (D_{26}), *and the red dash line is the limit of our measurement.*

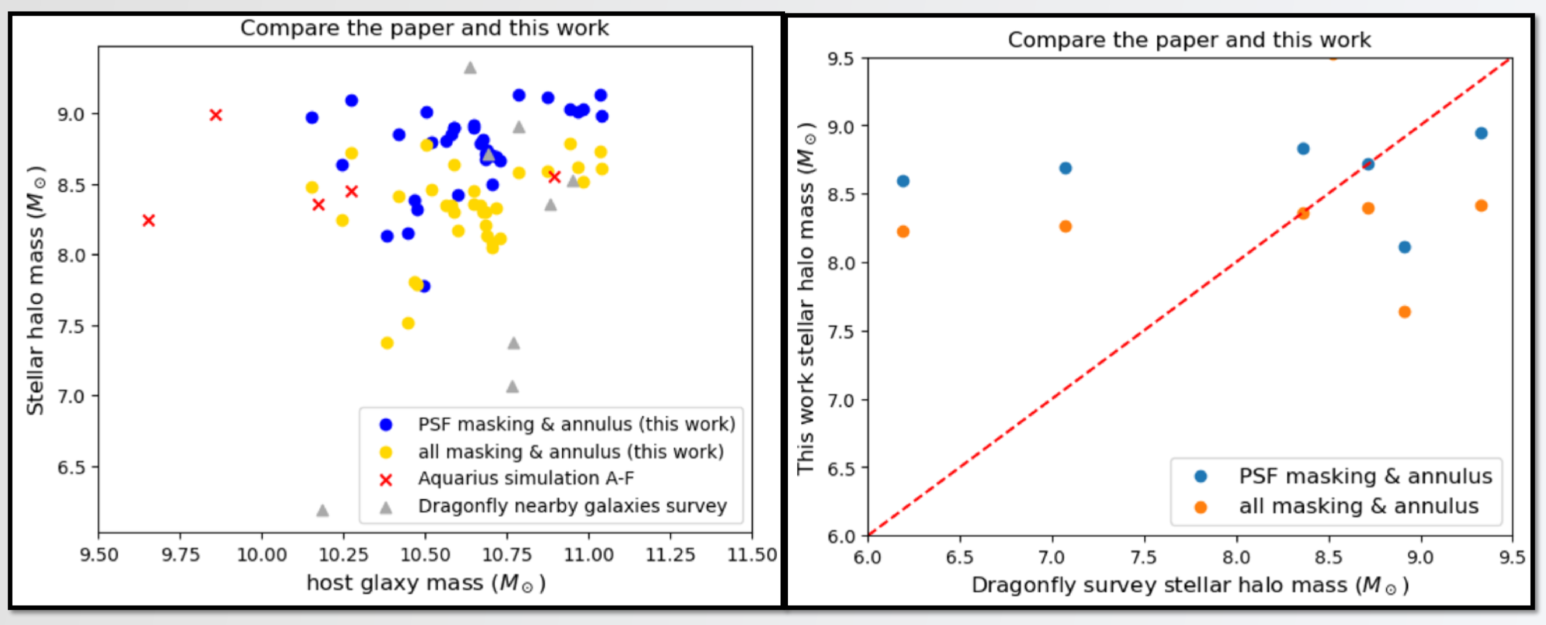


Fig. 5: *We compared our results to simulations* (Cooper et al. 2010) *and observations from the Dragonfly project* (Merritt et al. 2016). *The mass scale of the stellar halos is roughly similar (left panel), but they are some difference that we are trying to understand. Dragonfly measurements of the stellar halos are* $>5R_h$ *, so it seems reasonable that they're offset lower. The right panel compares the stellar halo mass we get and the results for the same galaxies from the Dragonfly survey.*