Finding the selection function of DES galaxy-galaxy strong lenses

Aidan Cloonan

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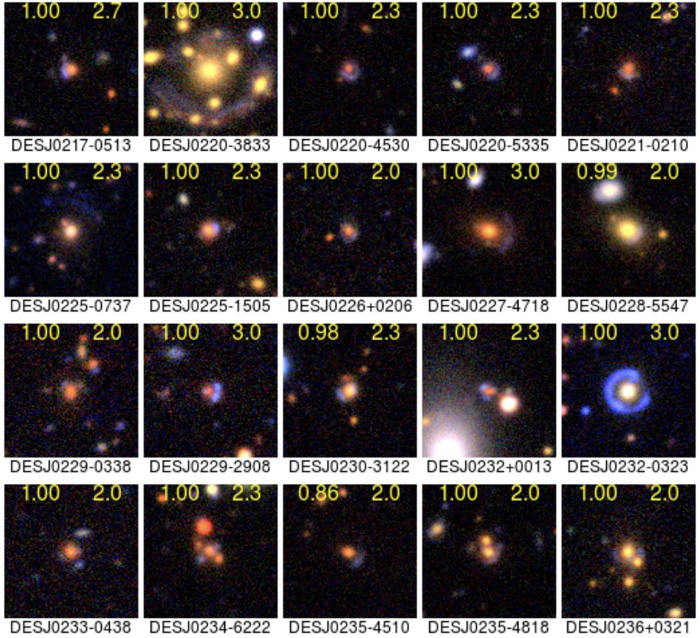
Introduction

- Crucial to probe mass distributions to study galaxy structure and evolution → where strong-lensing comes in!
- We must see how representative galaxy-galaxy lenses are of luminous red galaxies (LRGs) more broadly
- **Primary question: Are DES galaxy-scale lenses drawn from the broader galaxy population? Or do they constitute their own?**

Figure 1. A handful of the 511 galaxy-galaxy candidates found in DES Y3 (Jacobs, et al., 2019) using convolutional neural networks.



Data Selection

- Two datasets
  - 10000 randomly selected objects (LRGs) from DES Y3 redMaGiC catalog
  - 511 galaxy-galaxy lens candidates (Jacobs, et al., 2019), found in DES Y3
- Image cutouts obtained from publicly released DES DR2 catalogs using DESaccess
- So far, we have processed 3990 LRGs and the 98 ‘easiest’ lens candidates (i.e. galaxy-scale, and relatively easy to mask), and plan to
  - ‘Easiest’ lens candidates were visually selected, based on perceived SNR and Einstein radius
  - Group-scale lenses were excluded

Methods

Source masking for all objects

- Other objects in line of sight
- Background source (for SL systems)

Multi-band Sérsic profile fitting using PyImfit and MCMC sampling

Use fit results to calculate photometric observables for both datasets

1D statistical comparison in each observable, using a two-sample Kolmogorov-Smirnov test

Modeling Process

$$I(x,y) = I(r) = I_\mathrm{e} \exp\left\{-b_n\left[\left(\frac{r}{R_e}\right)^{1/n} - 1\right]\right\},$$

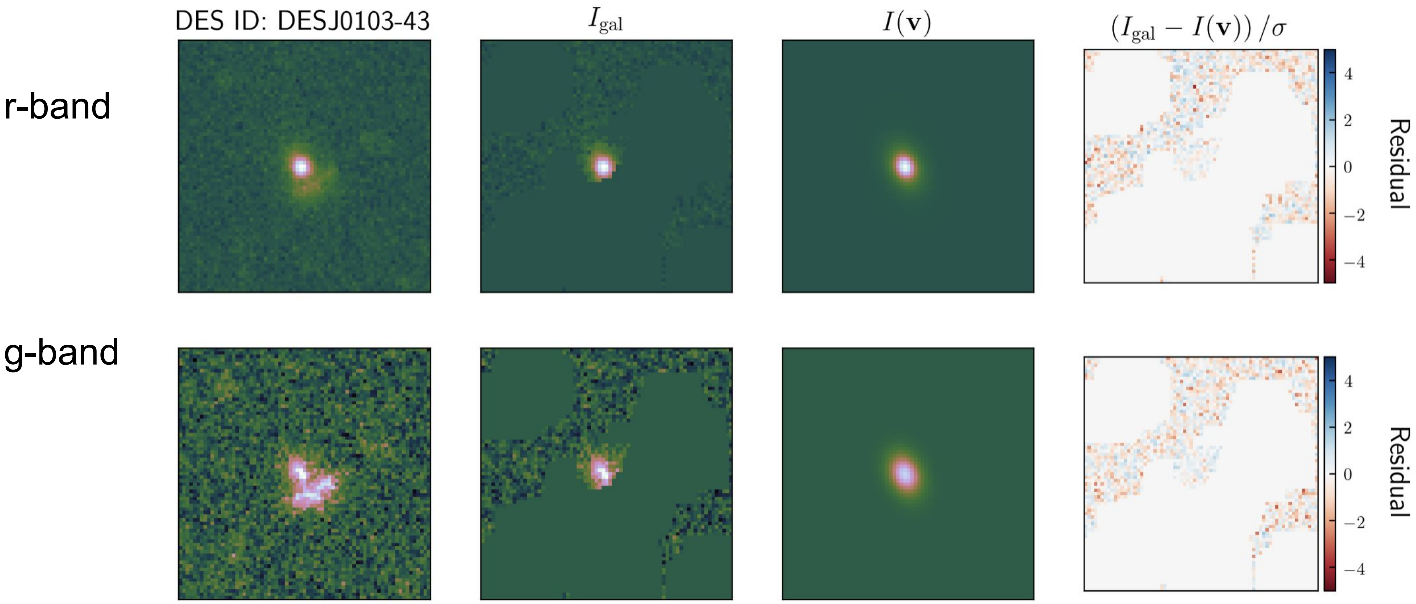


Figure 2. Visualization of the modeling process in r-band and g-band. From left to right: raw coadded image, masked image, modeled galaxy image, residual. r-band in top row, g-band in bottom row. The galaxy's brightness profile is modeled in both bands simultaneously.

Results

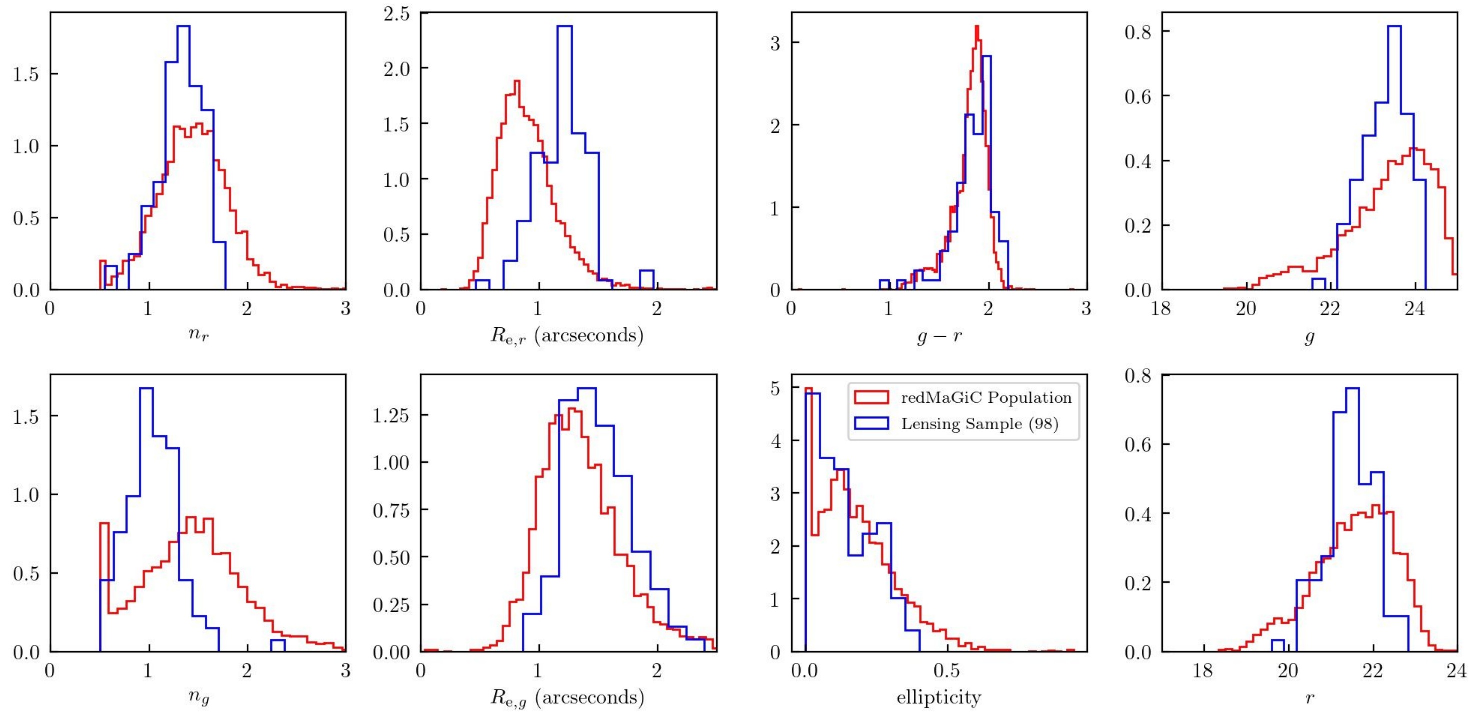


Figure 3. Histograms of the 8 observables of interest for both populations: Sérsic indices and half-light radii in both filters, ellipticity, g- and r-band aperture magnitudes, g - r color.

Results

Observable	K-S Statistic	p_{KS}
n_r	0.265	2.14×10^{-6}
n_g	0.495	$< 10^{-15}$
$R_{\mathrm{e},r}$	0.530	$< 10^{-15}$
$R_{\mathrm{e},g}$	0.258	4.30×10^{-6}
ellipticity	0.132	0.0635
g	0.254	6.25×10^{-6}
r	0.221	1.39×10^{-4}
$g - r$	0.168	7.97×10^{-3}

Table 1. Kolmogorov-Smirnov test statistics and corresponding p-values in each of the 8 observables of interests, comparing the two samples.

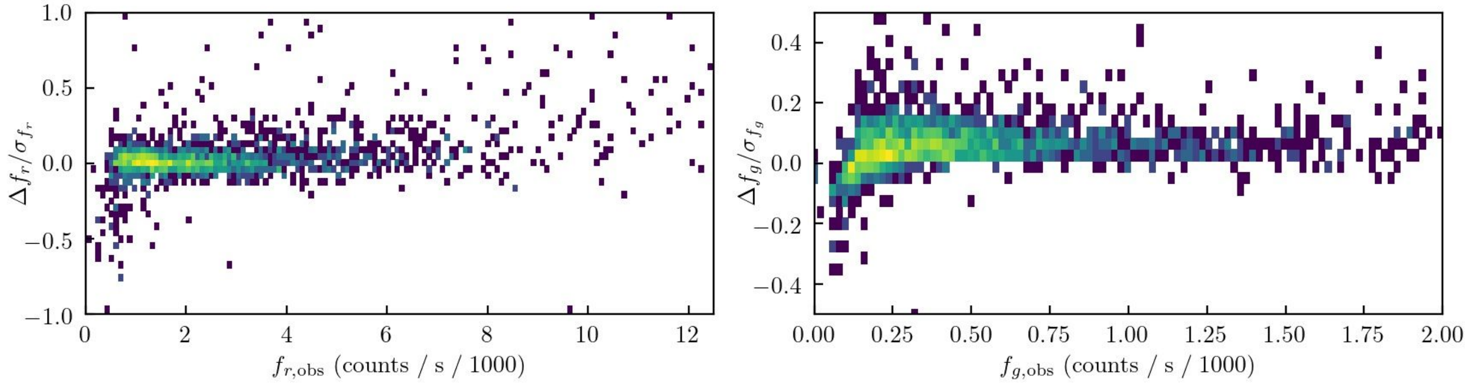


Figure 4. 2D histograms plotting observed aperture flux (x-axes) plotted against a residual between observed aperture and model aperture flux (y-axes) for a sample of 4000 LRGs from the DES Y3 redMaGiC catalog, in both r-band (left) and g-band (right). All flux values were calculated using a 1.841” by 1.841” box as the aperture.

Discussion

- Current results may indicate that the lenses tend to be brighter and larger in projected size than the non-lensing galaxies.
- Current analysis may show a significant amount of selection bias, but I do not interpret this as conclusive evidence that the lensing sample constitutes a different population.
- Limitations and systematics
  - At this stage, measurement of uncertainties is rather tentative.
  - For LRGs, SNRs are higher in red filters, so photometry may be better constrained in r-band than in g-band
  - Possible bias present for the brightest and faintest LRGs (shown in the previous slide)
  - Possible selection bias in my own cuts to the lensing sample?

Next Steps

- Make improvements to masking algorithms
- Carry out MCMC modeling
- Multivariate statistical comparisons
- Match or bin by photometric redshift

The goals are to increase the lensing sample size and then carry out more robust tests for selection bias.