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Galaxy Zoo: Classifications for Galaxies in HST Legacy Imaging

Lead Author and other Galaxy Zoo science team

* *This publication has been made possible by the participation of more than 200,000 volunteers in the Galaxy Zoo project. Their contributions are individually acknowledged at* `http://www.galaxyzoo.org/volunteers`.

E-mail: lead.author@university.edu

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ABSTRACT

Data release paper for GZ Hubble

1 INTRODUCTION

2 SAMPLE AND DATA

2.1 Summary of HST Legacy Survey Imaging

- AEGIS has1 orbit each (2200 seconds) in F606W (V band) and F814W filter and has been dithered to 0.03 ”/pixel; the imaging covers 710 arcmin^2.
- GOODS targeted 2 fields, GOODS-N and GOODS-S, imaging in 4 filters – F435W (B), F606W (V), F775W (i), and F850LP (z). The mean exposure times vary, from 1000 - 2100 seconds. The images have been dithered to a pixel scale of 0.03 ”/pixel and covers at total area of 320 arcmin^2 (160 arcmin^2 per field). The filters that Griffith et al uses for the colored images were F606W and F775W for GOODS-N and F606W and F850LP for GOODS-S.
- COSMOS has 1 orbit (2028 seconds) in the F814W (I band) filter and has been dithered to 0.05 ”/pixel; it covers the largest area, 1.8 deg^2.
- GEMS has 1 orbit (2160 and 2286 seconds) in the F606W and F850LP filters, with a pixel scale of 0.03 ”/pixel; it covers 800 arcmin^2

3 REDSHIFT DEPENDENT CLASSIFICATION BIAS

We can’t do what we did in Bamford et al. (2009) for the original GZ or Willett et al. (2013) for GZ2 because these both depended on the assumption of no redshift bias. In the GZH samples the redshift range is so large that we expect to find redshift evolution of the types and morphologies of galaxies which are seen.

So we made images of the same galaxy at a variety of redshifts using input images from the SDSS (cite the SDSS) and the FERENGI code (cite Ferengi) to produce images from these typical of those observed in the HST surveys.

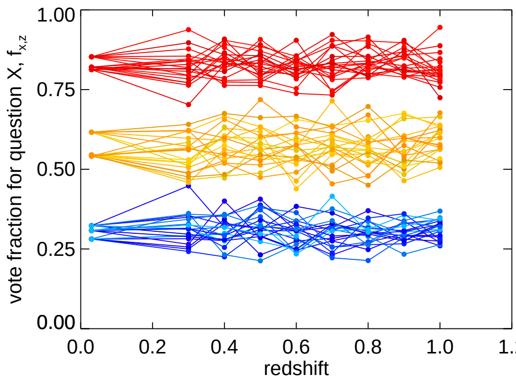

Figure 1. Fake results of the FERENGI redshifting exercise. For three vote fraction levels and thee surface-brightness levels each, we show the evolution of the 7 evolutionary corrections used with redshift.

3.1 Selection of Input Galaxies

We select 288 different galaxies in SDSS imaging to run through the FERENGI code.

The selection spanned a variety of galaxy morphologies (as indicated by GZ2 classifications), with a range of surface brightnesses, and also picked ideal **need Edmond to fill in** for different target redshifts in HST imaging.

The selection criteria for the different morphological categories is summarised in Table 1. The surface brightness selection was (1) low: $\mu > 21.5$magarsec^2; (2) mid: $20.5 < \mu < 21.5$magarsec^2; and (3) high: $\mu < 20.5$magarsec^2.

There were four “target redshifts” ($z = 0.3, 0.5, 0.8$ and 1.0), and from these points the images were redshifted in $\Delta z = 0.1$ bins up to $z = 1.0$. In addition different evolution models were assumed in FERENGI. This evolution

Table 1. Summary of morphological categories

Morphology	Label	Selection	N_{objects}
Features	Yes	$p_{\text{features}} > 0.8$, $p_{rmodd} < 0.1$	12
	Int	$0.3 < p_{\text{smooth}} < 0.6$, $p_{\text{odd}} < 0.1$	12
	No	$p_{\text{smooth}} > 0.8$, $p_{\text{odd}} < 0.1$	12
Merger	No	$p_{\text{features}} > 0.8$, $p_{\text{odd}<0.1}$, $p_{\text{merger}} < 0.1$	12
	Int	$p_{\text{odd}} > 0.5$, $0.1 < p_{\text{merger}} < 0.4$	12
	Yes	$p_{\text{odd}} > 0.5$, $p_{\text{merger}} > 0.4$	12
Edge-on	Yes	$p_{\text{edgeon}} > 0.8$, $p_{\text{features}} > 0.5$	12
	Int	$0.4 < p_{\text{edgeon}} < 0.8$, $p_{\text{features}} > 0.5$	12
	No	$p_{\text{edgeon}} < 0.2$, $p_{\text{features}} > 0.5$	12
Bar	No	$p_{\text{bar}} < 0.1$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} < 0.2$	24
	Int	$0.2 < p_{\text{bar}} < 0.4$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} < 0.2$	24
	Yes	$p_{\text{bar}} > 0.8$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} < 0.2$	24
Visible spiral	No	$p_{\text{spiral}} < 0.2$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} < 0.2$, $p_{\text{bar}} < 0.1$	12
	Int	$0.2 < p_{\text{spiral}} < 0.8$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} < 0.2$, $p_{\text{bar}} < 0.1$	12
	Yes	$p_{\text{spiral}} > 0.8$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} < 0.2$, $p_{\text{bar}} < 0.1$	12
Oblique Bulge Size	No	$p_{\text{nobulge}>0.6}$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} < 0.5$, $p_{\text{bar}} < 0.2$	12
	Int	$p_{\text{justnoticeable}} > 0.6$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} < 0.5$, $p_{\text{bar}} < 0.2$	12
	Yes	$p_{\text{obvious/dominent}} > 0.5^1$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} < 0.5$, $p_{\text{bar}} < 0.2$	12
Edge-on bulge shape	Round	$p_{\text{rounded}} > 0.5$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} > 0.5$	12
	Boxy	$p_{\text{boxy}} > 0.4$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} > 0.2$	12
	Non	$p_{\text{nobulge}} > 0.5$, $p_{\text{features}} > 0.5$, $p_{\text{edgeon}} > 0.5$	12

Table 2. Summary of FERENGI runs

Starting redshift	$N_{z\text{bins}}$	$N_{\text{evolution}}$	N_{runs}	N_{total}
0.3	8	7	56	4031
0.5	6	4	24	1728
0.8	3	3	9	648
1.0	1	3	3	216

is a crude mechanism that is suppose to mimic the brightness increase of galaxies with increasing redshift. The evolution mechanism allows us to make galaxies brighter as linear function of redshift, and that is it. It is an empirical addition to the magnitude of a galaxy of the form $M' = ez + M$, where M' is the corrected magnitude, e is the evolutionary correction in magnitudes. (i.e. $e = -1$ essentially brightens the galaxy by 1 magnitude by $z = 1$). **What values of e did we use?** Depending on the target, or starting redshift we ran FERENGI for several final redshifts and different evolution models as summarized in Table 2.

An example redshifted image is shown in Figure **??**.

4 SUMMARY

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