Galaxy Zoo Hubble: the fraction of passive disk galaxies decreases from z = 1.0 to z = 0.2

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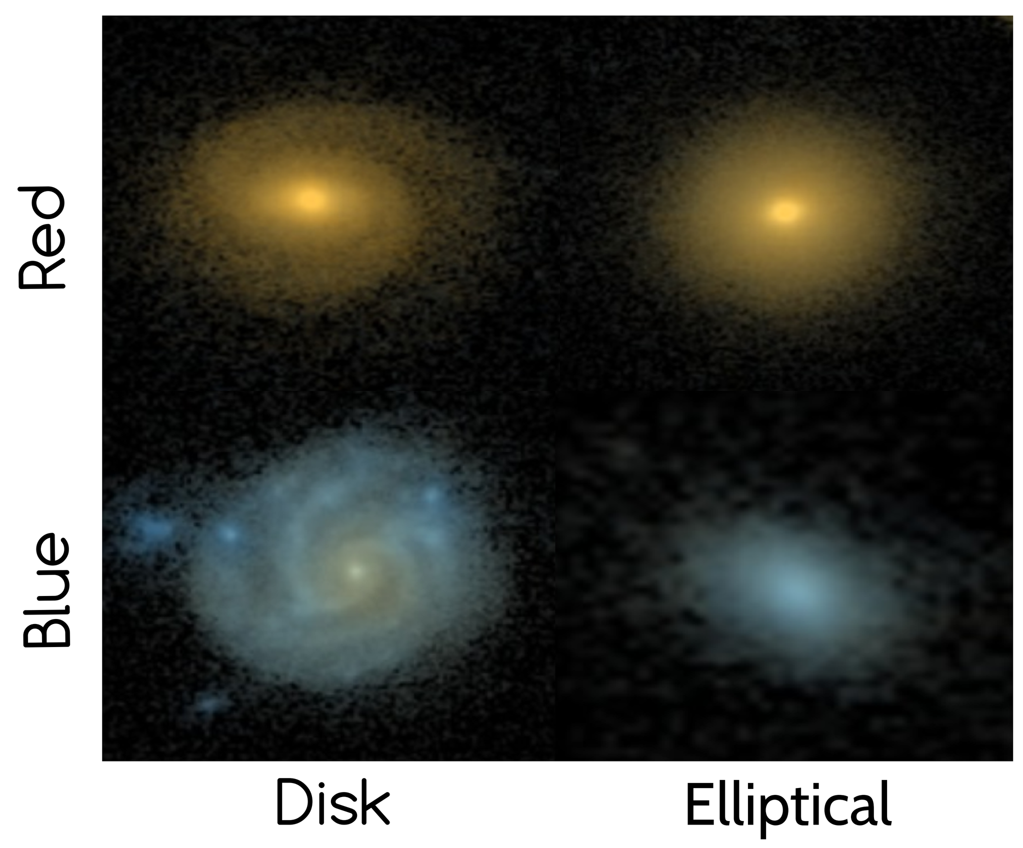
Abstract

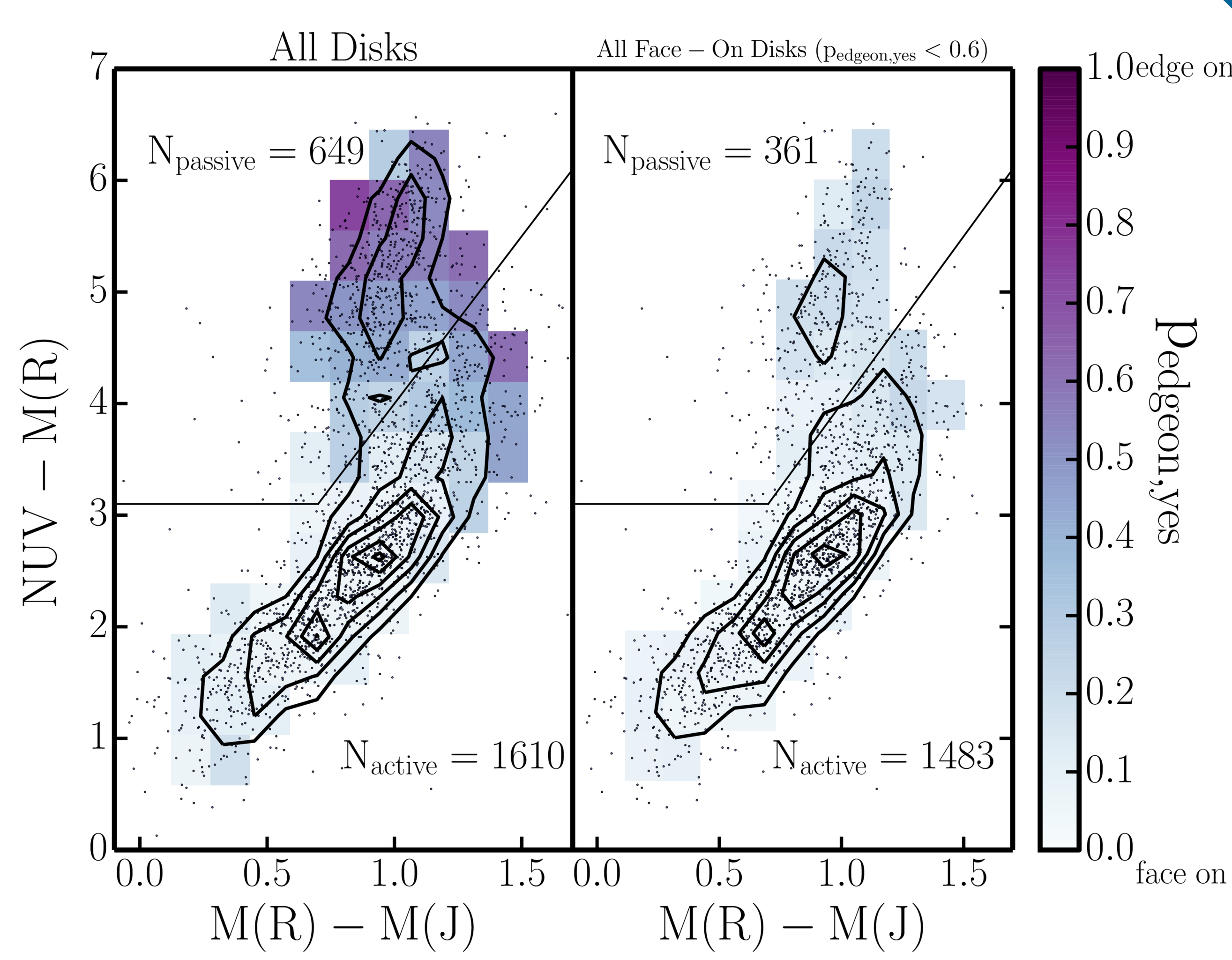


The transition of galaxies from the blue cloud to the red sequence is commonly linked to a morphological transformation from disk to elliptical structure. However, the correlation between color and morphology is not one-to-one, as evidenced by the existence of a significant population of red disks. As this stage in a galaxy's evolution is likely to be transitory, the mechanism by which red disks are formed offers insight to the processes that trigger quenching of star formation and the galaxy's position on the star-forming sequence.

To study the population of disk galaxies in the red sequence as a function of cosmic time, we utilize data from the Galaxy Zoo: Hubble project, which uses crowdsourced visual classifications of images of galaxies. We find that the fraction of disks in the red sequence decreases as the Universe evolves from z=1 to present day.

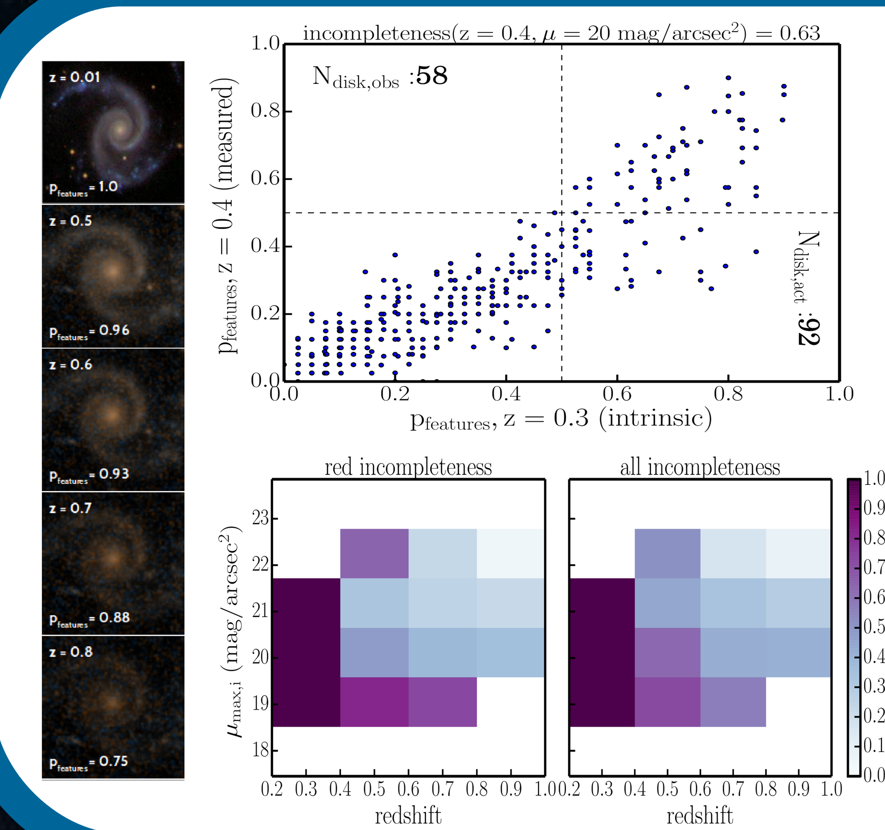
Passive Disk Selection

Our sample contains 1,844 disk galaxies in the COSMOS field which contained both morphological classifications from GZ: Hubble and rest-frame k-corrected colors from the UltraVISTA[3] catalog. Disk galaxies were identified using a cut of $p_{features} \geq 0.5$ (that is, 50% of GZ users identified the galaxy as a disk). We restrict the sample to bright galaxies by applying a surface brightness cut of $\mu < 21.5$ mag/arcsec^2.



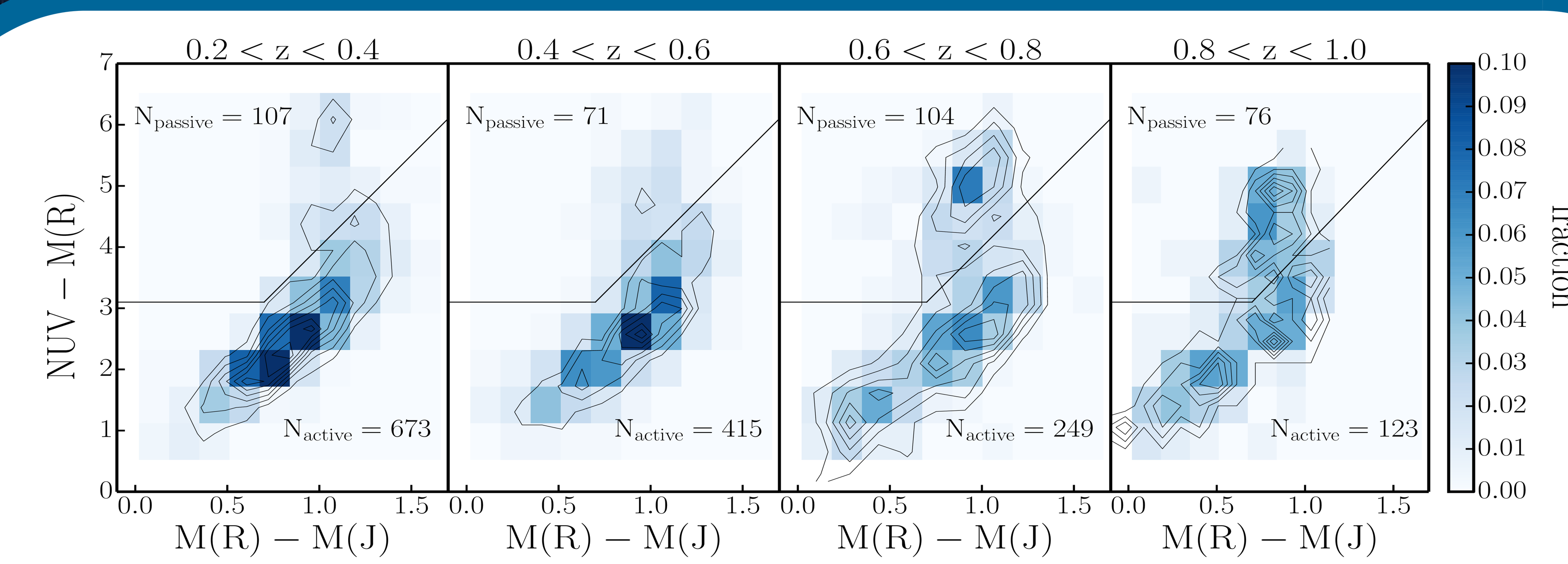
Passive disks were identified as those lying in the upper-left region of a NUV – MR vs. MR – MJ color-color diagram, as shown above. **Left:** The average $p_{edgeon,yes}$ value, which is the fraction of GZ users who identify the disk as edge-on, across the color-color space. We observe that a significant portion of disk galaxies in the passive region are highly inclined, indicating that many of these are actually dust-reddened. **Right:** We therefore place a cut on $p_{edgeon,yes} < 0.6$ so only low-inclined disks are included in the final sample.

FERENGI Incompleteness Correction

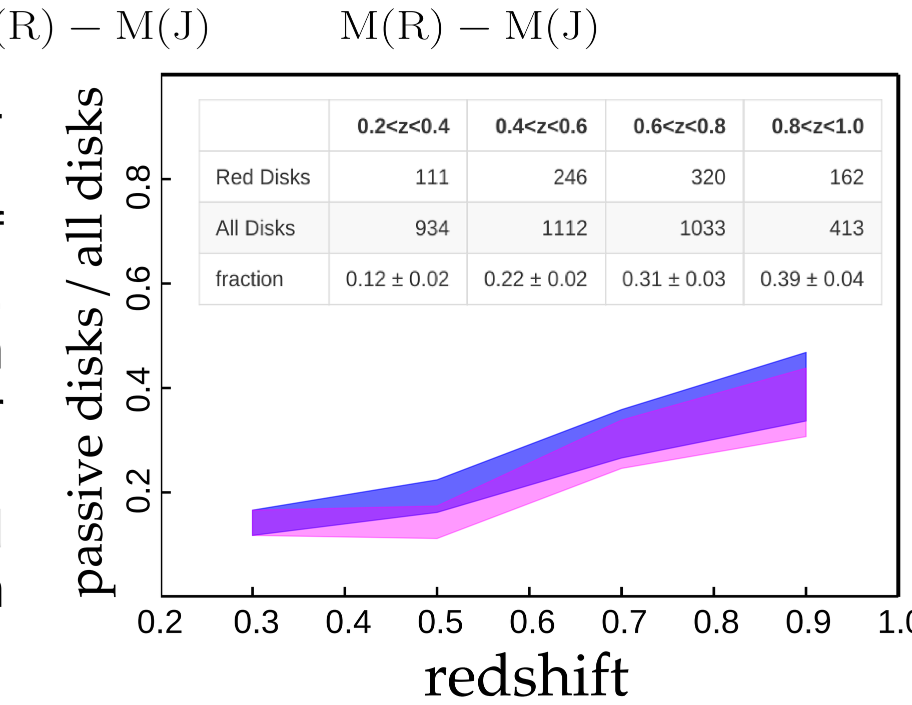


To account for the known effect that disks are more difficult to identify at high redshift, we quantify the effect of this bias by analyzing the drop in $p_{features}$ using data from simulated images. GZ users classified images of galaxies that had been artificially redshifted using the FERENGI[4] code (example galaxy on the left). We compute the incompleteness in the number of disks detected at a given z and μ by comparing the p_features values for the same galaxy at high and low redshift. We apply this correction factor in computing the passive disk fraction.

Results



Top: The fraction of disk galaxies across color-color space is shown for four redshift intervals. As redshift increases, so does the fraction of disk galaxies that lie in the passive region. **Right**: The fraction of disk galaxies in each redshift interval, both corrected for incompleteness (blue) and uncorrected (pink). We find in both the corrected and uncorrected data that **the passive disk fraction decreases from z = 1.0 to z = 0.2**.



	0.2<z<0.4	0.4<z<0.6	0.6<z<0.8	0.8<z<1.0
Red Disks	111	246	320	162
All Disks	934	1112	1033	413
fraction	0.12 ± 0.02	0.22 ± 0.02	0.31 ± 0.03	0.39 ± 0.04

Conclusions

The fraction of passive disk galaxies decreases from $39^{\pm 4}$ % to $12^{\pm 2}$ % as the Universe evolves from z = 1 to the present. This trend is consistent with an evolutionary model in which a significant portion of disk galaxies undergo a passive phase on their transition from disk to elliptical structure. Future work will investigate what mechanisms are capable of quenching star formation without immediately destroying the disk, and whether other detailed morphological structures (bulge, spiral arms, bars) influence this process.

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