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Can JWST Reveal the Hubble Sequence in the Early Universe?

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Background

Galaxies in the Local Universe have various morphological characteristics. A classification diagram, called the Hubble Sequence, was established by Edwin Hubble in the 1920's to categorize the different types. As time and technology has progressed, astronomers have been able to observe farther into our universe. Distant galaxies observed with the Hubble Space Telescope (HST) appeared to be irregular and clumpy (Driver et al. 1995)[1], leaving the inception of the Hubble Sequence in question. HST, however, is unable to resolve stellar structures in the early universe, but the newly launched James Webb Space Telescope (JWST) has better resolution due to its larger size and longer wavelength range. Early JWST data has shown that galaxies at six billion years after the Big Bang are not irregular, but disk galaxies. Disk morphology makes up a large portion of the galaxies at these and earlier times (Ferreira et al. 2022 and Kartaltepe et al. 2022)[2,3], differing from previous HST results. We will test this result with a new, larger sample of JWST data. The overall goal of this project is to study the onset of the Hubble Sequence and to investigate the correlation between the physical properties and morphologies of galaxies.

Data & Methods

Our data is retrieved from the Cosmic Evolution Early Release Science Survey (CEERS), one of the thirteen early release surveys for JWST. This survey imaged part of the Extended Groth Strip (EGS) in 2022 with the NIRCam in seven different filters in 10 separate pointings: four in June and six in December. The results from this paper only used the June data, but we will add the December data as soon as it becomes available.

In order to study disk galaxies, we created a sample of galaxies from CEERS that have a stellar mass greater than $10^9\ M_\odot$ and have a redshift ranging from z=0.5 (nine billion years after the Big Bang) to z=6 (one billion years after the Big Bang). With these constraints, we obtained a sample size of 2,352 galaxies. These galaxies were visually identified by the author and placed into the following categories: spherical, disk, irregular, compact, and unclassifiable. We need multiple people to classify each galaxy to reduce bias from a single inspector. To promote quick and easy classifications from a large group of volunteers, we are constructing a project through Zooniverse, a citizen science web portal that is designed to allow the public to take part in real time research. Our project will ask users a set of questions to determine the morphology of individual galaxies.

Results

Our preliminary results show that disk galaxies make up a significant amount of galaxies, even at four billion years ago. Figure 1 shows that disk galaxies evolve make up almost half of the galaxies across all redshifts while irregular galaxies increase with increasing redshift. We have also observed that the fraction of spiral galaxies declines with increasing redshift. At the redshift range 0.5-1, galaxies with a stellar mass greater than $10^{10}\ M_\odot$ make up about half of all disk galaxies observed and steadily declines to 0 by z=3. Galaxies below $10^{10}\ M_\odot$ make up about 20% of galaxies at the lowest redshift range and drop rapidly by z=1.

Future Work

In the future, we will investigate the physical properties of the different morphological groups. Our Zooniverse project will be released to students at the University of Missouri Columbia. It will provide robust visual inspection for 2,000+ galaxies by the end of 2023. These galaxies will be run through GALFIT, a data analysis algorithm that fits 2D functions to images and derives quantitative properties, by the end of 2023. We will be able to combine the morphological and physical properties to determine whether there are any correlations between these properties in the early universe. This project will be finished by mid 2024.

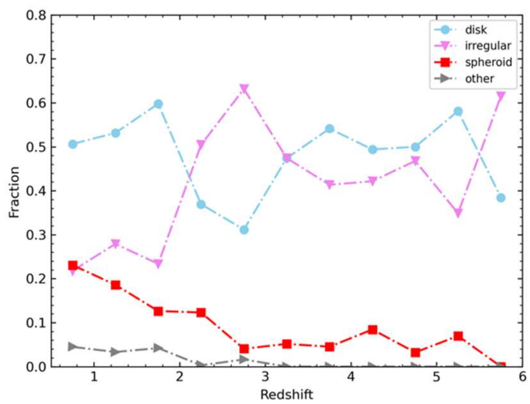

Figure 1: Plot of morphology fraction vs. redshift. This plot shows that disk galaxies are the dominant morphology type across almost all redshifts (Kuhn et al. in prep).

NASA Relevance

This work will look at physical properties of galaxies, as well as their morphological type, in the early universe that have not been previously studied extensively in the infrared. We will further NASA's Cosmic Origins Program goal to understand galactic evolution, especially the earliest galaxies. Our project will continue to build on our existing knowledge and may even shed some light on the evolution of our own Milky Way galaxy.

Acknowledgements

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Biography

Vicki Kuhn is from West Lafayette, IN and is currently a physics graduate student at the University of Missouri Columbia studying the morphology of galaxies. She received her Bachelor of Science in Physics at Loyola University Chicago and her Master of Science at the University of Minnesota, Duluth.

References

[1] Driver, S. P., Windhorst, R. A., & Griffiths, R. E. 1995, ApJ, 453, 48, doi: 10.1086/176369

[2] Ferreira, L., Conselice, C. J., Sazonova, E., et al. 2022, arXiv:2210.01110. doi:10.48550/arXiv2210.01110

[3] Kartaltepe, J. S., Rose, C., Vanderhoof, B. N., et al. 2022, arXiv:2210.14713. doi:10.48550/arXiv.2210.14713