Analyzing Morphological Types and Color Indices of Galaxies in Clusters

By Ethan Tang

AUTHOR BIO

Ethan Tang is seventeen years old and is attending his senior year at Westwood High School. He has interests in the field of computer science, astrophysics, and data science, and is passionate about music. At school, he plays the saxophone in the Westwood Band, and he spends his afternoons at marching band rehearsals. At home, he also enjoys playing the piano.

ABSTRACT

Galaxy morphology is important for understanding the formation and evolution of galaxies within a cluster, as morphological type has been attributed to distance and location. The colors of galaxies are also very useful for analyzing their properties. This paper analyzes galaxy morphology, looking at the ratio of Early Type Galaxies to Late Type Galaxies within galaxy clusters at changing redshifts. Furthermore, the color indices of these galaxies are explored as the paper looks into how the colors of galaxies differ at various redshifts. It was found that Early Type Galaxies were dominant in clusters at redshifts less than one, while Late Type Galaxies were dominant in those at redshifts greater than one. Additionally, Early Type and Late Type Galaxies had similar changes in colors from redshifts 0-1, with Late Type Galaxies always appearing more blue than Early Types.

INTRODUCTION

The concepts that this research focuses on help the astronomical community better understand the different galaxy morphological types and their characteristics. Galaxy morphology is useful for understanding the formation as well as evolution of galaxies, and future research on galaxy formation will benefit from our research as well. By analyzing color filter values, we gain more knowledge about stars, as color is an indicator of star formation. The color of galaxies also tells us about the temperature of galaxies and helps us further explore galaxy morphology. By analyzing clusters, we can see how these galaxies interact in a more crowded environment. Redshift helps astronomers compare the distances of objects that are far away. This paper looks at galaxy clusters at varying redshifts, aiming to find patterns about how the properties of galaxies within these clusters change as a function of redshift.

METHOD

This research collected data from three main sources: Literature searches, the SIMBAD database, and SDSS data. SIMBAD proved to be the most impactful out of these three, providing data on galaxy clusters, galaxies within clusters, morphological types, and redshift. To find the other data points, spectroscopic data from the SDSS database was utilized. Using the u and r color magnitudes of each galaxy, the color magnitudes of u-r were compared to the value of 2.2 to determine the morphological type of each galaxy. If the resulting color index value was greater than 2.2, then the galaxy was classified as an Early Type. If it was less than 2.2, it was classified as a Late Type. SDSS provided the necessary data for the redshift, B magnitude, and V magnitude, which were used to analyze the color indices. A variety of software tools aided in analyzing this data through graphs. These tools included Jupyter Notebooks, Numpy, Matplotlib, and Pandas. The research employed Pandas through Jupyter Notebooks to make .csv data usable in graphs. With the .csv file in Jupyter Notebook, Matplotlib was used to create scatter plots comparing the percentages of Early and Late galaxies at our redshift intervals.

RESULTS

It was found that at the lowest redshift bin, Early Type and Late Type Galaxies are almost equal in frequency. As the redshift increases, Early Type Galaxies begin to dominate until galaxy clusters at redshift 1.5. At this point, the frequencies are equal again and from then on, Late Type Galaxies dominate, making up over 90% of the galaxy cluster at the highest redshift observed. Additionally, the color indices of Early Type and Late Type Galaxies followed a very similar pattern as the redshift increased. Initially, the color index value increases, signifying that the galaxies are appearing more red At redshifts 0.75 to 1, this value drops significantly. Overall, the color index values of Late Type Galaxies are less than the color index values of Early Type Galaxies at every redshift bin.

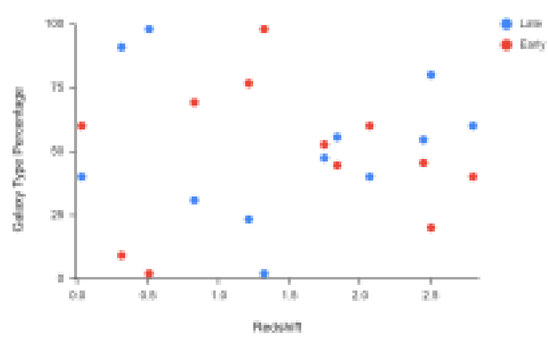

Figure 1. *Percentages of ETGs and LTGs in clusters at different redshifts*

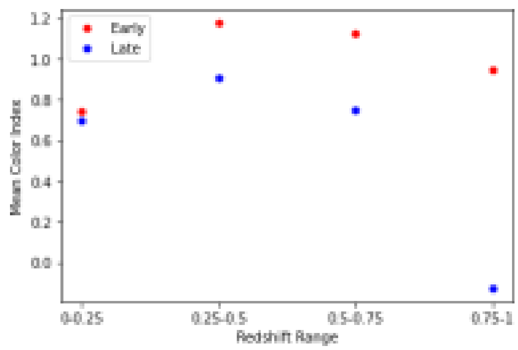

Figure 2. *The average color indices (B-V) of different types of galaxies at different redshifts.*

DISCUSSION

The results obtained from the study were supported by other research papers. Specifically, Durret et al. (2015) and Tamburri et al. (2014) found similar results. One of the graphs included in Durret et al. (2015) was almost identical to the one produced from this research. They only looked at redshifts from 0-1 and concluded that at the lowest redshift, the different morphological types are almost equal in number. Additionally, they found that Early Type Galaxies were dominant at low redshifts, in line with our results. Tamburri et al. (2014) analyzed greater redshifts as well, and they gathered that Late Galaxies dominated overall, which can be seen in our graph at greater redshifts.

CONCLUSION

In this research, through an analysis of galaxy morphology and color indices within galaxy clusters at varying redshifts, it was found that the ratio of Early Type Galaxies to Late Type Galaxies in these clusters changes with redshift. At lower redshifts, the two types of galaxies are roughly equal in frequency, but as redshift increases, Early Type Galaxies begin to dominate, continuing until a redshift of around 1.5, at which point the frequencies equalize again and beyond that, Late Type Galaxies become the dominant type. Additionally, the color indices of both Early and Late Type Galaxies followed similar patterns as redshift increased, increasing and appearing redder at first, but dropping at redshifts between 0.75 and 1. The significance of this finding lies in the fact that it helps improve our understanding of the dynamics of galaxy clusters over time. It not only contributes to our understanding of the evolution of galaxies within clusters, but also gives us insight into the factors shaping the galaxies we observe today.

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