

Abstract

This study investigates the contamination of high-redshift galaxy candidates by ultra-cool dwarfs (UCDs) identified by Aganze et al. (2022) in extragalactic surveys, focusing on M-type, L-type, and T-type stars. Using simulations based on the Hubble Legacy Fields (HLF) and 3D-HST catalogs, we analyzed how UCDs are misclassified as high-redshift galaxies through color-color selection and EAzy photometric redshift techniques. We found that contamination is primarily driven by the distribution of UCDs relative to selection criteria, with M-type stars contributing significantly. The Bayesian Information Criterion (BIC) effectively minimizes contamination, whereas Chi-square evaluation results in higher misclassification rates (25–75%), likely due to survey field and filter differences. Future work will refine contamination estimates by incorporating galactic coordinates and expanding UCD samples to improve high-redshift galaxy classification and luminosity function measurements.

Introduction

High-redshift galaxy candidates can be contaminated by brown dwarfs. M-type stars can mimic galaxies at redshifts of approximately 4.5 to 5.5, while cooler L- and early T-type stars have been identified as contaminants in galaxies at around redshift 6. Understanding this contamination is crucial for accurately identifying high-redshift galaxies. This study aims to quantify the impact of brown dwarf contamination in extragalactic surveys and improve galaxy classification methods.

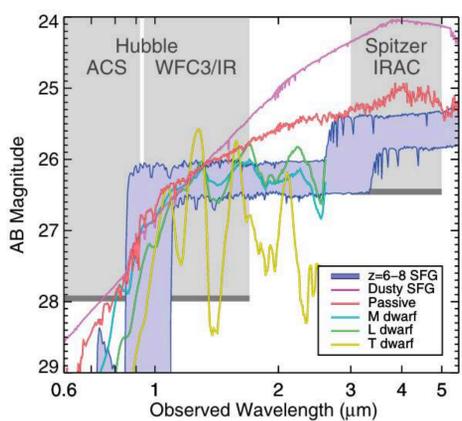


Fig 1: A comparison of the SEDs of star-forming galaxies at high redshift with possible lower redshift contaminants.

The purple shaded region shows model spectra of high-redshift star-forming galaxies.

Cyan, green, and yellow curves denote M, L, and T dwarf star.

Finkelstein et al. (2016)

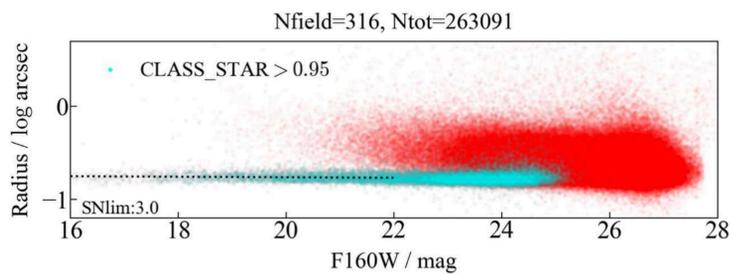


Fig 2: Those selected as point sources using CLASS_STAR From Morishita et al. (2021)

Methods used to select high-redshift galaxies

Color selection

To select galaxy candidates, we identify objects that fall into the "dropout" regions of color-color diagrams. We examine selection criteria from Roberts-Borsani et al. (2022) and Bouwens et al. (2015) to classify high-redshift galaxies.

Photometric redshift Estimation

This technique estimates the redshift of objects by comparing their observed colors to models or templates. Additionally, it can provide a probability distribution for the estimated redshift. Galaxies are fitted using the EAzy v1.3 templates, while stellar objects are fitted using the SPEX templates.

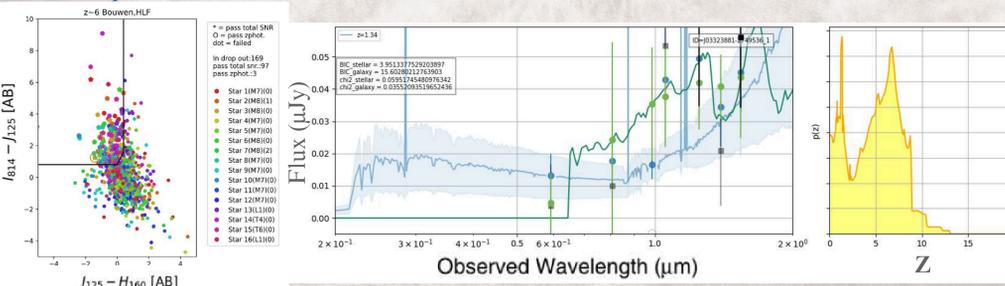


Fig. 3: The left panel illustrates the selection of candidates that fall within the dropout region and are classified as high-redshift galaxies. The right panel presents the object's SED across various filters alongside the template SED, highlighting the statistical value indicating the quality of the fit, as well as a probability distribution within the graph.

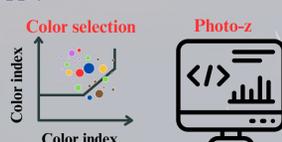
Methods used in this studies

List of UCDs



Make UCDs Fainter
(Adjust magnitudes to 24.5, 25.0, ..., 27.0.)
(Incorporate SNR values from extragalactic datasets.)

Apply Classification methods.



Get Misclassification Rate.



Position and example of UCDs

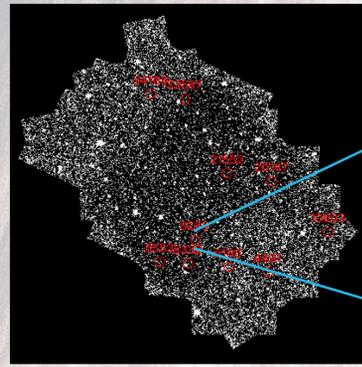
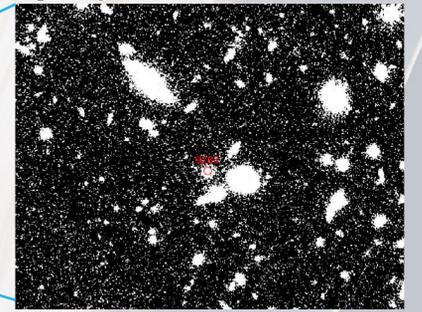


Fig. 4: Examples of UCDs analyzed based on their positions and morphological characteristics.



Results

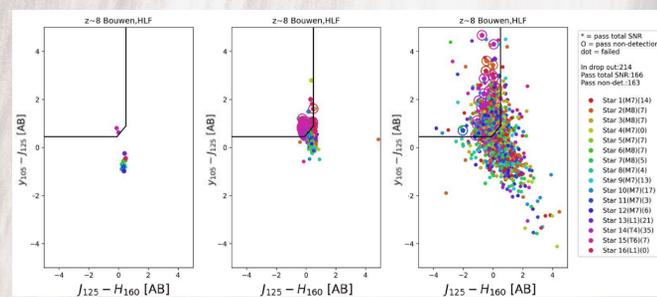


Fig 5: Position shifts of objects showing negative trends as magnitude increases.

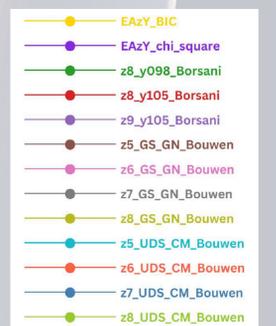


Fig 6: Label of each criterion

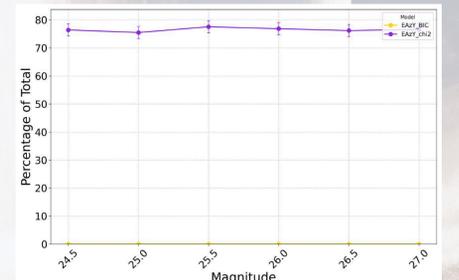
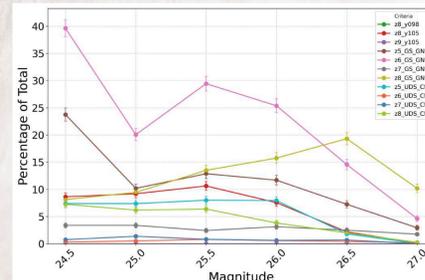


Fig. 7: Percentage of each criterion for color selection (left) and goodness of fit (right).

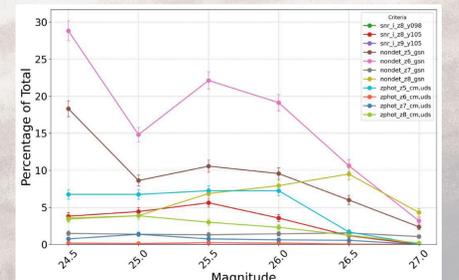
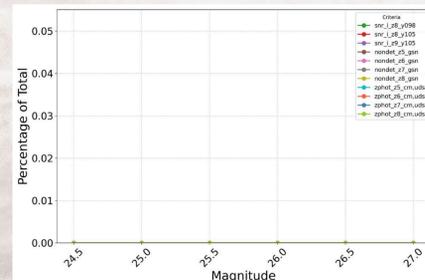


Fig. 8: EAzy BIC (left) and Chi-square (right) with supplementary criteria across different magnitudes.

The misclassification rate is determined by the number of high-redshift galaxy candidates selected through color criteria, combined with EAzy BIC and Chi-square analysis. The results show that BIC effectively reduces the misclassification rate, while the Chi-square method yields a misclassification rate ranging from 0% to 30%. Additionally, the color selection graph demonstrates that the number of high-redshift candidates decreases as the original object moves further from the dropout region boundary.

Conclusion

The misclassification rate in the color selection method depends on the object's initial color position before noise is added and the catalog is made fainter. An increase in M-type candidates significantly raises the contamination rate, while variations in L-type and T-type candidates have a smaller impact. When the reduced chi-square value cannot be computed, alternative metrics such as the Bayesian Information Criterion (BIC) should be used for a more accurate assessment of template suitability and misclassification rates.

Reference

Aganze, C., Burgasser, A. J., Malkan, M., et al. (2022, January). Beyond the Local Volume. I. Surface Densities of Ultracool Dwarfs in Deep HST/WFC3 Parallel Fields. *ApJ*, 924(2), 114.
Bouwens, R. J., Illingworth, G. D., Oesch, P. A., et al. (2015, April). UV LUMINOSITY FUNCTIONS AT REDSHIFTS $z = 4$ TO $z = 10$: 10, 000 GALAXIES FROM HST LEGACY FIELDS*. *ApJ*, 803(1), 34.
Roberts-Borsani, G., Morishita, T., Leethochawalit, N., et al. (2022, March). The Physical Properties of Luminous $z \geq 8$ Galaxies and Implications for the Cosmic Star Formation Rate Density from ~ 0.35 deg² of (Pure-)Parallel HST Observations*. *ApJ*, 927(2), 236.