Near-infrared characterization of ultra-diffuse galaxies in Abell 2744 by JWST/NIRISS imaging

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ABSTRACT

We present a search and characterization of ultra-diffuse galaxies (UDGs) in the Frontier Fields cluster Abell 2744 at $z = 0.308$. We use JWST/NIRISS F200W observations, acquired as part of the GLASS-JWST Early Release Science Program, aiming to characterize morphologies of cluster UDGs and their diffuse stellar components. A total number of 22 UDGs are identified by our selection criteria using morphological parameters, down to stellar mass of $\sim 10^7 M_\odot$. The selected UDGs are systematically larger in effective radius in F200W than in HST/ACS F814W images, which implies that some of them would not have been identified as UDGs when selected at rest-frame optical wavelengths. In fact, we find that about one third of the UDGs were not previously identified based on the F814W data. We observe a flat distribution of the UDGs in the stellar mass-size plane, similar to what is found for cluster quiescent galaxies at comparable mass. We also find 10 potential candidates with disturbed morphologies, a previously overlooked but important population as a possible progenitor of the local UDGs. Our pilot study using the new JWST F200W filter showcases the efficiency of searching UDGs at cosmological distances, with 1/30 of the exposure time of the previous deep observing campaign with HST. Further studies with JWST focusing on spatially-resolved properties of individual sources will provide insight into their origin.

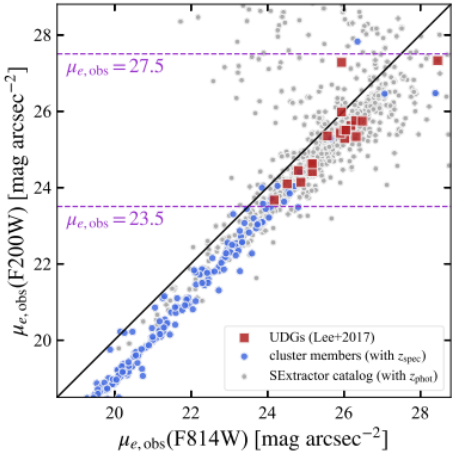
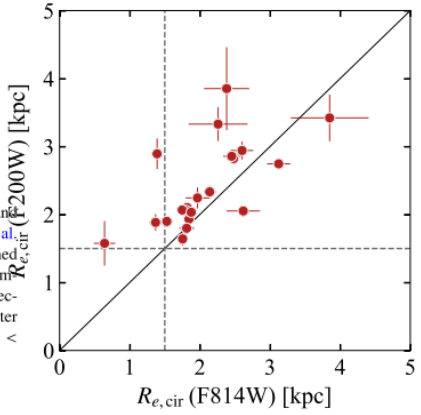


Figure 1. Comparison of surface brightness between HST/ACS F814W and JWST/NIRISS F200W filters. The red symbols are UDGs reported in Lee et al. (2017). The blue symbols are the compilation of spectroscopically confirmed cluster galaxies (Mahler et al. 2018; Richard et al. 2021). The grey symbols are objects detected in SExtractor with $0.108 < z_{\rm phot} < 0.508$ (Section 3.1). The surface brightness in the F200W filter is systematically brighter than the F814W filter. We adopt a criterion of $23.5 < \mu_{e,\rm obs}$(F200W) < 27.5 mag arcsec^{-2} (dashed purple) for reducing the candidates of UDGs.

Abell 2744周囲で検出した天体の
HST/F814WとJWST/F200Wでの
← Fig 1: 表面輝度μ_e
↓Fig.3: 有効半径R_e

- ■＝HSTでもUDGとIDされていたもの
- F200Wの方が明るく(Δμ~0.41)大きい(ΔR~114%)。
- 波長や基準によってはUDGとIDされないことも。



JWST/NIRISSによるz~0.3 Ultra-Diffuse銀河の構造

- Ultra-Diffuse Galaxies (UDGs)
  - 銀河団に付随して見られる銀河種族。
  - 普通の銀河と同程度の大きさでありながら、質量は2-3桁小さい。
  - 明確な基準は無い。→ データ・手法によっては異なる進化を経た種族が混ざってしまう恐れがある。
  - シミュレーションでは、銀河団内UDGの50%は潮汐作用で形成され、銀河団中心に多く見られる。
- 起源・形成過程
  - Internal: retention of high spin halo(?), stellar feedback
  - External: 潮汐相互作用やtidal heating(運動エネの増加?)による星構造の膨張

→ JWSTの集光力と近赤外線感度によって、より昔（＝formation epochに近い？）UDGを静止系可視で調べる。

Figure 3. Comparison of the circular effective radius of the UDGs, measured in the F200W and F814W filters. The one-to-one relation is shown in the black solid line. The dashed lines indicate $R_{e,\rm cir} = 1.5$ kpc.

Fig.6: UDGのM_s-R_e分布→

- Non-UDGはlow-mass QG (■, ■) に似た分布。
- UDGはM_sによらずサイズはほぼ一定。
- 同じM_sではQGより~2.6倍大きい → UDGとQGは異なる種族か。

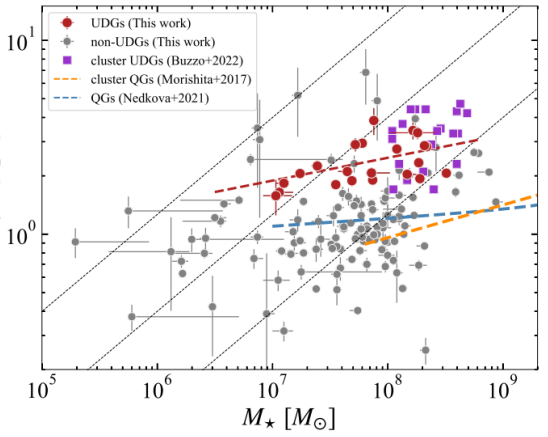
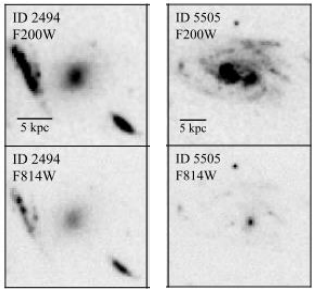


Figure 6. Distribution of the UDGs (red) and non-UDGs (grey) in Abell 2744 in the stellar mass-size plane. A compilation of the spectroscopically confirmed UDGs in nearby clusters (Buzzo et al. 2022) are shown in purple squares. The red dashed line is the result of a single power law fit for the UDGs. The orange and teal dashed lines are the best-fit law for cluster QGs in the HFF cluster ($0.2 \le z \le 0.7$; Morishita et al. 2017) and QGs at $0.2 \le z \le 0.5$ (Nedkova et al. 2021). The black dashed lines denote constant surface stellar mass density ($\Sigma_\star = 0.1, 1, 10\ M_\odot {\rm pc}^{-2}$).



左：UDG例 (@z~0.3):

右：Disturbed例: μ_e, R_eは基準を満たすが、GALFITのresidualが大きかったもの。Ongoing merger? HSTでは左coreは見えない→heavily dusty?

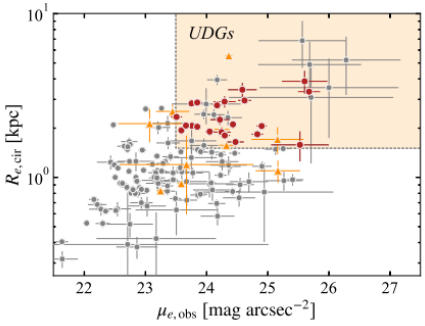


Figure 2. The location of the UDGs (red circles) and 'disturbed' galaxies (orange triangles) in the effective surface brightness ($\mu_{e,\rm obs}$) - the circular effective radius ($R_{e,\rm cir}$) plane of NIRISS F200W. The highlighted region in beige signifies the criteria of UDGs. The rest of non-UDGs are shown in grey circles. A total number of 34 out of 141 objects fulfill the criteria, and 12 of them are excluded from the final UDG due to their high Sérsic index ($n > 2.5$).

←Fig2: 本研究でのUDG選択基準
境界付近のnon-UDGもtidal heatingを受けてUDGに進化する可能性もある。

- ◆ JWSTの驚異的な性能により、UDGの観測がさらに促進される。
- ◆ UDGの定義や波長間の差異 (→ 形態進化？) の研究も今後進める。