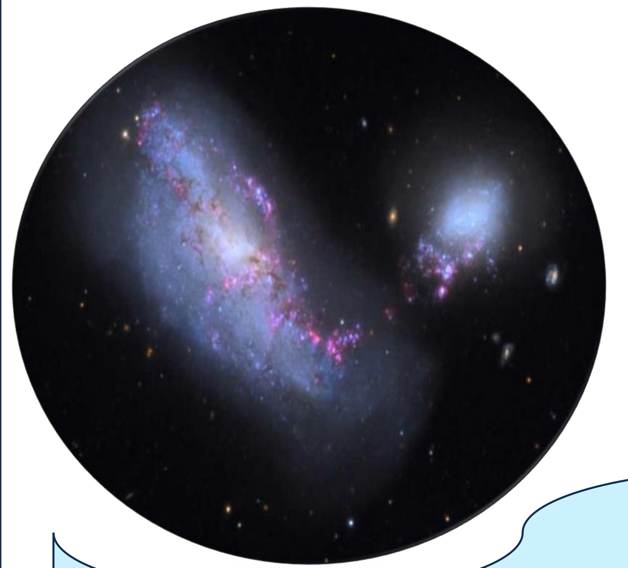
Impact of dwarf galaxies interactions on their star forming properties

GALEX + UVIT study

Rakshit Chauhan[1] & Smitha Subramanian[1]

1 Indian Institute of Astronomy (IIA), Koramangala II Block, Bangalore-560034, India

Introduction



- ΛCDM model predicts large structure formation occurs in hierarchical manner.
- Merger and interaction play a crucial role in growth and evolution of these structures.
- High mass regime ($M_* > 10^{10} M_\odot$), relatively well studied in both observations (Barton et al. 2000; Ellison et al. 2000, 2010; Bickley et al. 2022) and simulations (Toomre & Toomre 1972; Mihos & Hernquist 1994a,b, 1996; Patton et al. 2020; Brown et al. 2023)
- Dwarf galaxies constitute the most abundant population of galaxies across all redshifts. (Karachentsev et al. 2013, Loveday 1997)
- Majority of mergers are expected within these Dwarfs. (De lucia 2016; Fakhouri et al. 2010)

- Interactions could give rise to the formation of distinctive structures such as rings, tidal tails, stellar streams, bridges, and plumes.
- Such tidal interactions can trigger star formation activities and ultimately build the outskirts of their host galaxy this kind of assembly projected to be scale-free
- Nearly 1 : 10 mergers are expected to be prominent drivers to the mass growth

HST image of NGC 6503

Scientific Objective

- To study the effect of interaction among Dwarfs by comparing SF activity in interacting and non-interacting Dwarfs
- To study spatial distribution of Star Forming clumps.
- Mostly young O and B type stars are brighter in UV wavelengths.
- FUV can trace stars up to ~ 100 Myr

Sample Selection & Characterization

GALEX sample

Dwarf Galaxies selected from Kado-fong et al. 2020

Imaging

HSC-SSP S18A DR, in g, r and i band

Spectroscopy

- Spectra from SDSS (Reid et al. 2016) and GAMA (Baldry et al. 2018)
- Hα line measurements by GAMA and SDSS spectroscopic databases

Isolated Dwarfs

- 3D physical separation of at least 1 Mpc from the nearest massive galaxy
- Galaxies projected closer than 0.01° to a massive galaxy removed

UVIT sample

Dwarf Galaxies selected from Pustilnik & Tepliakova 2011

Optical and Holmberg radii, effective radii and observed ellipticity; B-band surface brightness profiles

M_* estimation;

mass-luminosity-color relations

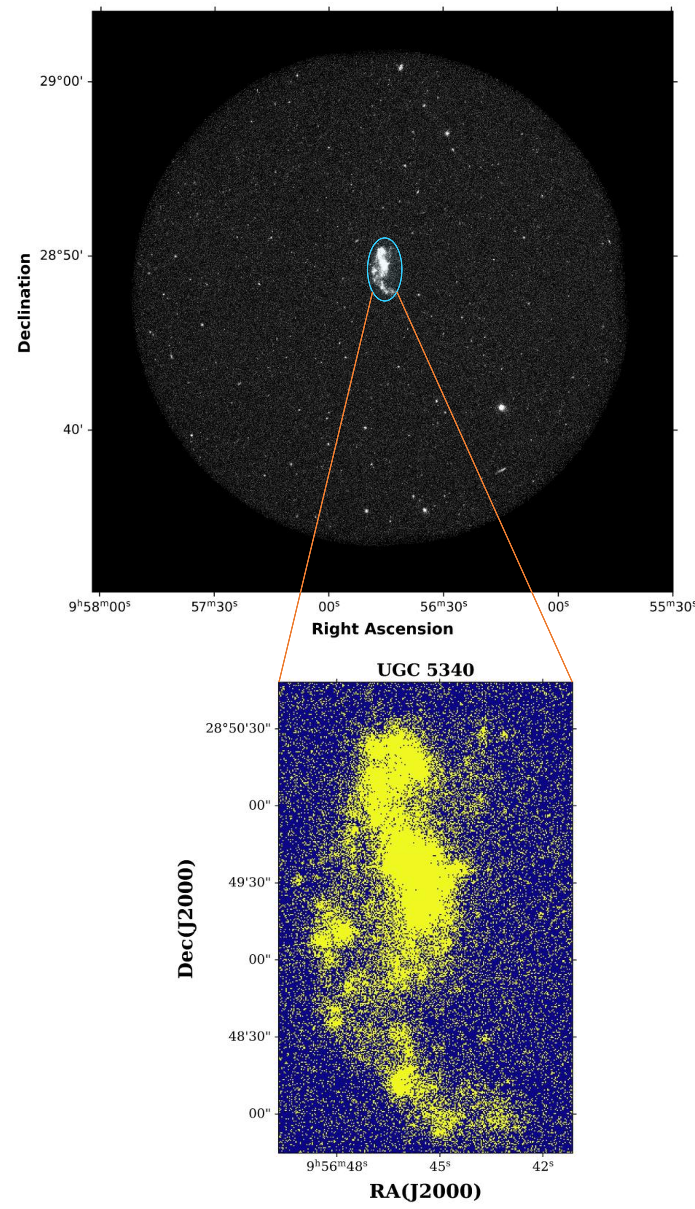
g band luminosity

(g-i) color by (Zibetti et al. 2009)

Distance estimation;

$D(\mathrm{Mpc}) = v_{dist}/73\ (\mathrm{km\ s^{-1}\ Mpc^{-1}})$, v_{dist} from (Pustilnik & Tepliakova 2011)

Observations and Data Reduction



Deep and higher resolution FUV observations were conducted using UVIT onboard AstroSat, during A11 cycle.

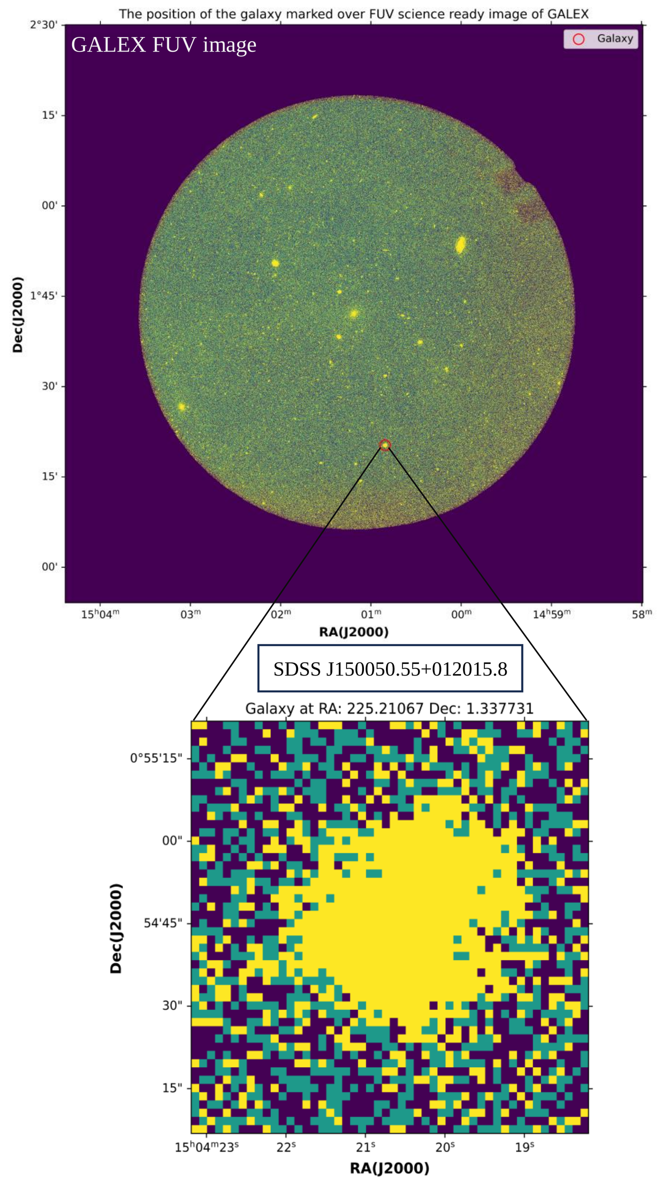
Images of each orbit are distortion drift corrected, aligned and combined with the help of a customized data reduction software CCDLAB

Star Formation Rate

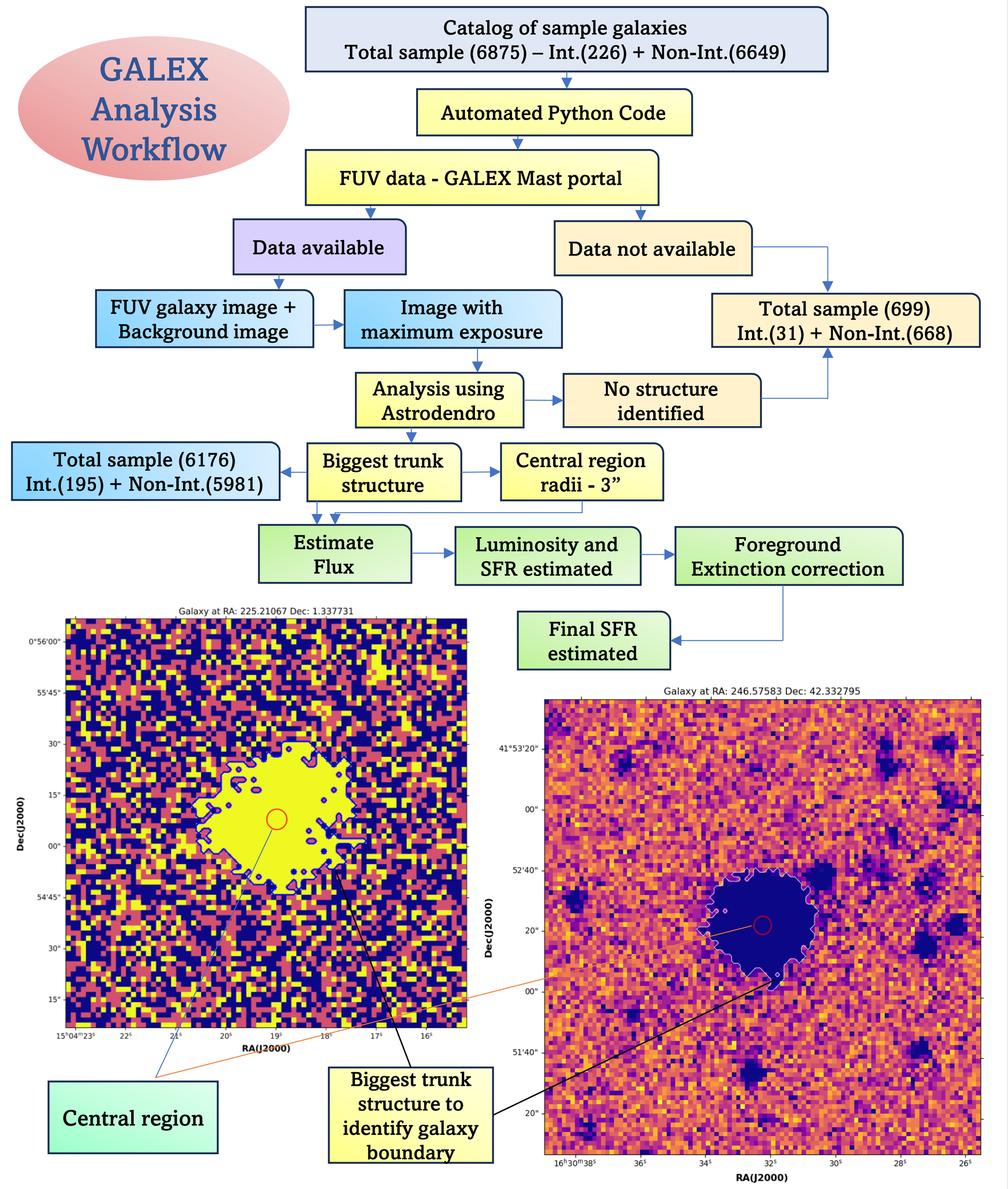
$L_{FUV} = 4\pi D^2 \times Flux$

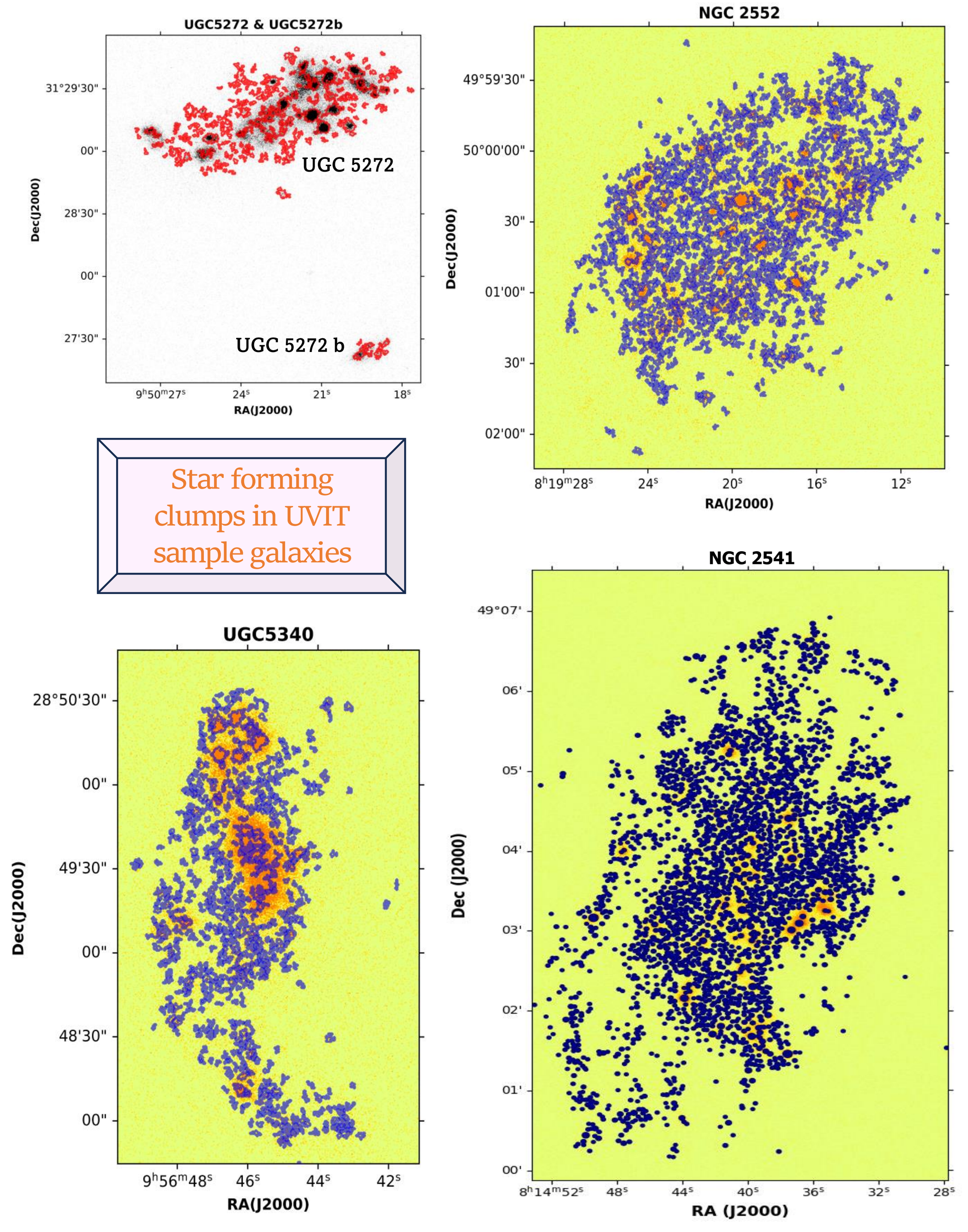
$SFR_{FUV} = 4.42 \times 10^{-44}\ L_{FUV}$

(Murphy et al. 2011)



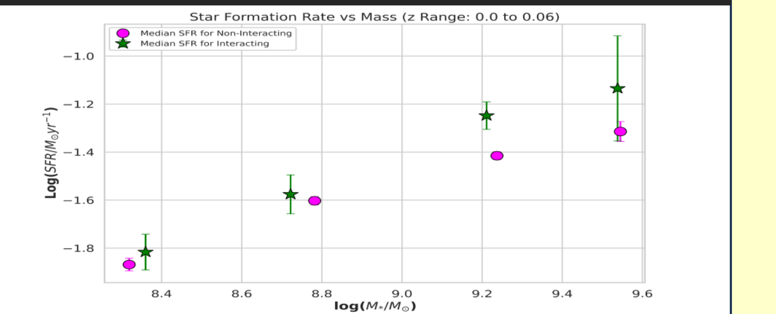
Analysis





Results

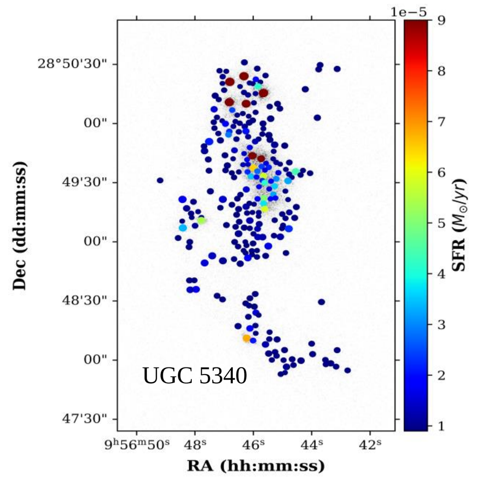
Redshift z \ $\log(M_*/M_\odot)$	8.0 – 8.5	8.5 – 9.0	9.0 – 9.5	9.5 – 10.0
	Median SFR (Interacting / Non-Interacting)			
0.00 – 0.02 (Interacting)	0.0107 ± 0.0045 (9)	0.0125 ± 0.0077 (7)	0.04994 ± 0.0044 (6)	0.00604 ± 0.0162 (2)
0.00 – 0.02 (Non-Interacting)	0.00725 ± 0.0005 (105)	0.01199 ± 0.001 (94)	0.02213 ± 0.0035 (54)	0.02265 ± 0.027 (4)
0.02 – 0.04 (Interacting)	0.01997 ± 0.0057 (14)	0.02655 ± 0.0012 (35)	0.04949 ± 0.0017 (32)	0.1077 ± 0.0684 (4)
0.02 – 0.04 (Non-Interacting)	0.01231 ± 0.0001 (299)	0.02074 ± 0.0005 (443)	0.03023 ± 0.00004 (354)	0.03901 ± 0.004 (54)
0.04 – 0.06 (Interacting)	0.0090 ± 0.0117 (2)	0.03343 ± 0.0095 (7)	0.06603 ± 0.008 (33)	0.0902 ± 0.659 (7)
0.04 – 0.06 (Non-Interacting)	0.02550 ± 0.0027 (93)	0.03223 ± 0.0007 (507)	0.04234 ± 0.0008 (707)	0.05357 ± 0.0038 (145)

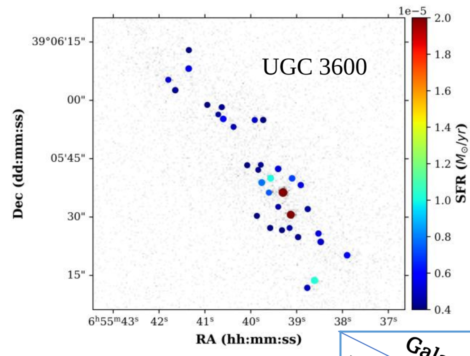


Redshift z \ $\log(M_*/M_\odot)$	8.0 – 8.5	8.5 – 9.0	9.0 – 9.5	9.5 – 10.0
	SFR Enhancement			
0.00 – 0.02	1.482 ± 0.723	1.04 ± 1.4	2.257 ± 0.77	0.267 ± 1.83
0.02 – 0.04	1.622 ± 0.672	1.28 ± 0.115	1.637 ± 0.136	2.761 ± 2.636
0.04 – 0.06	0.353 ± 0.937	1.037 ± 0.38	1.56 ± 0.293	1.684 ± 15.4

Redshift z \ $\log(M_*/M_\odot)$	8.0 – 8.5	8.5 – 9.0	9.0 – 9.5	9.5 – 10.0
	Central SFR Enhancement			
0.00 – 0.02	1.366 ± 0.757	2.029 ± 0.875	2.452 ± 2.34	1.213 ± 1.916
0.02 – 0.04	1.376 ± 0.327	0.938 ± 0.076	1.307 ± 0.097	2.353 ± 0.903
0.04 – 0.06	0.376 ± 0.027	1.098 ± 0.892	1.175 ± 0.075	0.542 ± 0.433

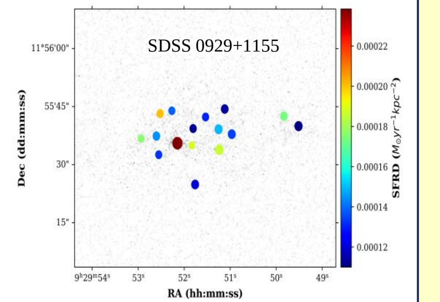
Redshift z \ $\log(M_*/M_\odot)$	8.0 – 8.5	8.5 – 9.0	9.0 – 9.5	9.5 – 10.0
	Outer SFR Enhancement			
0.00 – 0.02	1.902 ± 1.077	0.706 ± 0.651	2.667 ± 0.208	0.161 ± 0.497
0.02 – 0.04	1.857 ± 0.462	1.672 ± 0.130	1.684 ± 0.103	2.892 ± 2.135
0.04 – 0.06	0.303 ± 0.623	1.359 ± 0.343	1.828 ± 0.104	2.132 ± 10.13





Properties \ Galaxies	SDSS 0852+1350 (Interacting)	SDSS 0929+1155 (Non-Interacting)
M_* ($\times 10^7 M_\odot$)	2.76	2.98
D (Mpc)	23.08	27.89
SFR ($\times 10^{-4} M_\odot/yr$)	0.37 - 3.86	0.4 - 3.58
Clump size (pc)	89.5 – 329.7	258 – 692

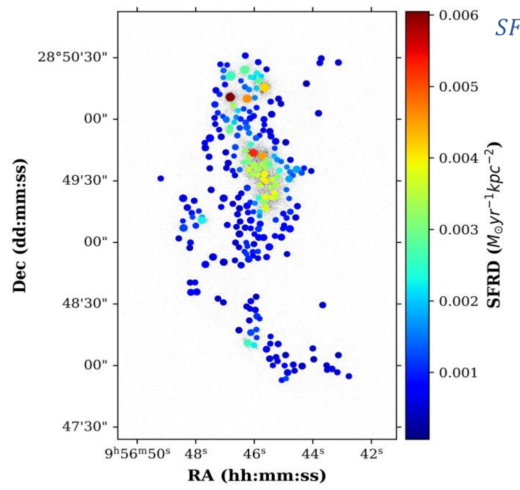
Properties \ Galaxies	UGC 5340 (Interacting)	UGC 3600 (Non-Interacting)
M_* ($\times 10^7 M_\odot$)	1.5	1.91
D (Mpc)	9.86	9.30
SFR ($\times 10^{-4} M_\odot/yr$)	0.042 – 2.95	0.038 – 0.44
Clump size (pc)	35.04 – 91.50	37.1 – 134.3

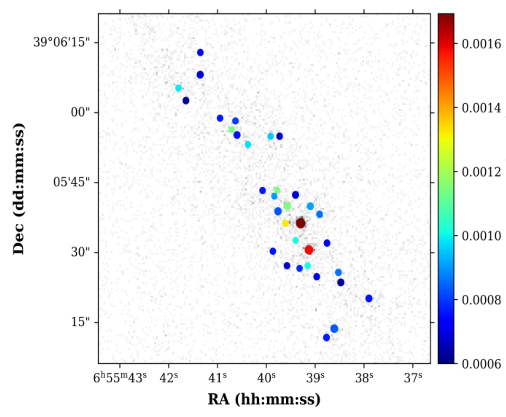


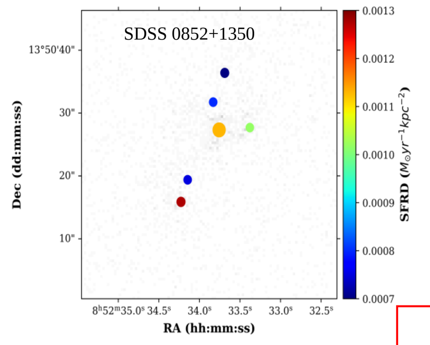
Spatial distribution of SFR

Spatial distribution of SFRD

$$SFRD = \frac{SFR\ (M_\odot\, yr^{-1})}{Area\ of\ clump\ (kpc^2)}$$







Median stellar mass

Interacting : $2.46 \times 10^7 M_\odot$

Non-Interacting : $2.76 \times 10^7 M_\odot$

Median SFR

Interacting - $(88.46 \pm 0.12) \times 10^{-4} M_\odot/yr$

Non-Interacting - $(21.59 \pm 0.15) \times 10^{-4} M_\odot/yr$

Summary & Conclusion

- We conducted a GALEX FUV study of 195 interacting and 5981 non-interacting dwarf galaxies to understand about the effect of dwarf-dwarf interaction (galaxies selected based on their disturbed morphology) on SF.
- Stellar mass range ($\sim 10^7$-$10^{10} M_\odot$) and redshift (0.00-0.12).
- FUV emission was observed to be widespread across galaxies.
- SFR in interacting galaxies observed to be enhanced by a factor of ~ 1.5 -- 2 times as compared to non-interacting galaxies across different mass and redshift. The enhancement factor is similar to what is predicted by simulations for dwarf-dwarf fly-by events.
- Outer as well as central 3″ region of interacting galaxies are also showing similar kind of enhancement, suggesting a widespread enhancement of SF due to interactions.
- We conducted a UVIT study of 19 interacting and 7 non-interacting dwarf galaxies ($M_* \sim 10^6$-$10^8 M_\odot$) in the Lynx-Cancer Void to understand the effect of dwarf-dwarf interaction on SF.
- Enhancement of ~ 4 times for SFR in interacting galaxies as compared to non-interacting galaxies
- SF is observed to be widely distributed throughout all the galaxies, contrary to what is observed in interacting massive galaxies.
- SFR and SFR Density is found to be more in the case of interacting galaxies as compared to that of non-interacting dwarfs.
- ***Our results imply that dwarf-dwarf interactions can affect SF and enhance SFR in dwarf galaxies***

References

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For any Query/Suggestion, email:rakshit.chauhan@iiap.res.in