COLOUR THEORY 101
MIXING GALAXIES

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Colour classification as a proxy for star formation is used to categorise galaxies. Technological advancements, such as the Integral Field Unit (IFU), help improve our understanding of galaxy evolution and star formation. Using the MUSE VLT in Chile, we set out to determine if there was any colour-based commonality to merging galaxies in three broad stages:

- Pair Galaxies (Left) - early stages of interaction, no matter exchanged.
- Merge Galaxies (Middle) - tidally locked; odd shapes; material exchange ongoing.
- Post-Coalescence Galaxies (Right) - merger complete; one single galaxy.

Mergers are an important part of the life-cycle of galaxies, often shown to be a driving force behind intense star formation and AGN activity. Studying galaxy colour as a proxy for star formation can help pinpoint the stage of a galaxy merger. Using this and the knowledge that young hot stars are blue and old stars are red, we seek to investigate whether galaxy interactions follow the same pattern - merger more blue with new star formation, post more red with old stars, and pair somewhere in between as gases start to compress into star formation.

SLICING THE CUBE

MUSE IFU datacubes consist of 2 spatial and 1 spectral dimension in wavelength steps ranging from approximately 4700 Å - 9000 Å. Datacubes for this analysis were masked to remove wavelengths > 8000 Å to eliminate atmospheric issues.
Slicing was used to pull the red and green colour bands from the datacube for density analysis:

* Red wavelength band: 6580 Å.
* Red wavelength half maximum: 1380 Å.
* Green wavelength band: 4640 Å.
* Green wavelength half maximum: 1280 Å.

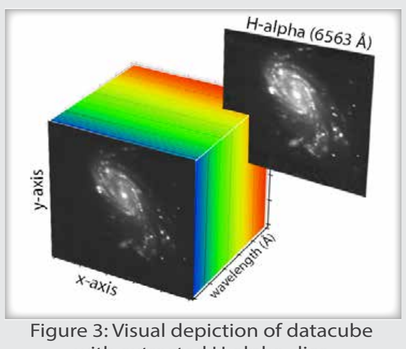


Figure 3: Visual depiction of datacube with extracted H-alpha slice

Using the same slicing method, H-alpha, OIII, and NII emission line ranges were also pulled from the datacube.
These ranges were saved as individual FITS files and exported to PixInsight for more advanced image generation and visual analysis.

Redshift was calculated by:

- Extracting the 1D spectra of each datacube.
- Masking around the 6500 Å - 7000 Å wavelength range.
- Finding the observed H-alpha emission spike.
- Subtracting the rest H-alpha emission of 6563 Å from the observed spike.

The comparison of calculated redshift vs NED redshift was found to have a margin of error of just 0.002.

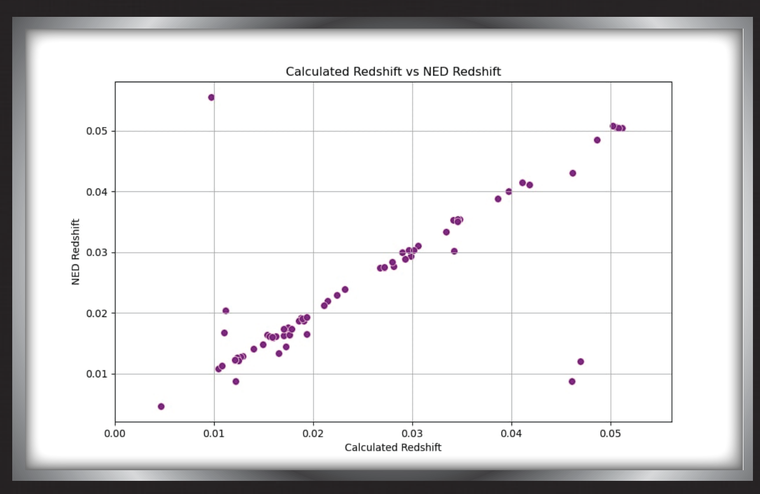


Figure 1: NED Accepted Redshift against Calculated Redshift.

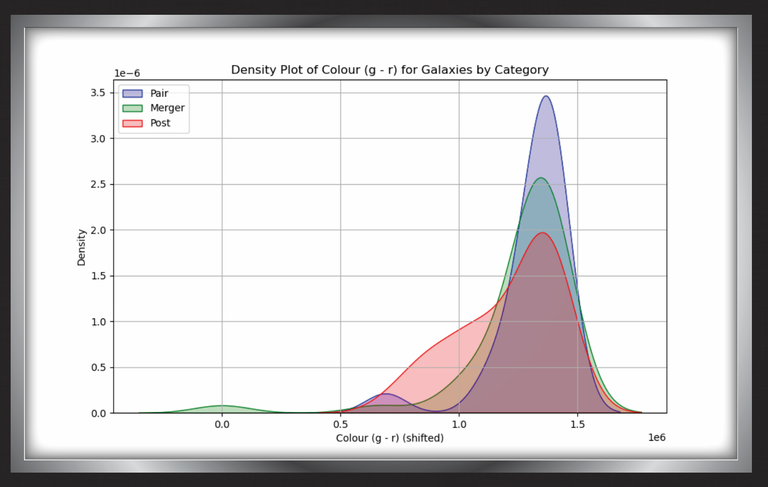
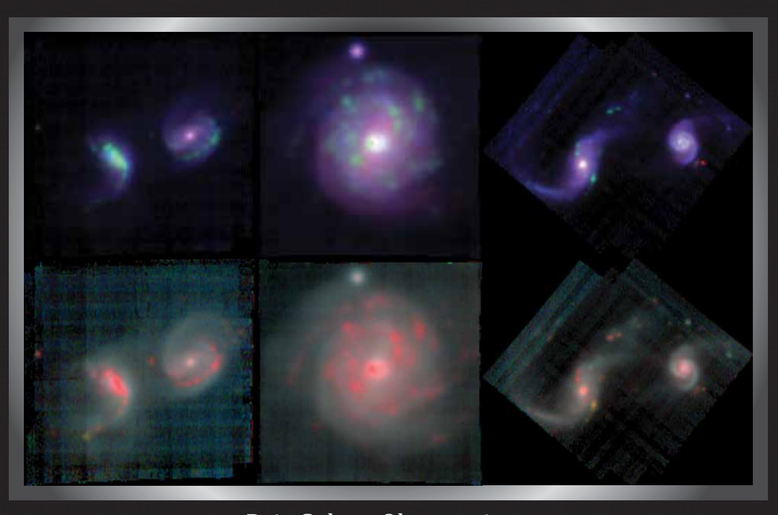


Figure 2: Colour-Density plot of galaxies in each category - Pair, Merger, and Post.

A density plot of the (g - r) spectrum of the categorised galaxies was generated to highlight trends in the data.

- All galaxy categories peak at approx. the same (g - r) shifted value.
- Post-co galaxies show a lazier climb, indicating a shift from green towards red.
- Pair galaxies show the steepest climb and the furthest shift towards the green spectrum.
- Supports the observation that post-co galaxies are predomainantly red, while pair and merger are blue.

- Top Images: Working with python-generated RGB images, the galaxies were visually categorised based on known merger features: Tidal tails and distinct shapes.
- Bottom Images: Emission-line enhanced images were also generated to examine underlying connections: H-alpha regions (red) indicating young star forming regions, OIII regions (green) indicating older star forming regions, reduced emissions (no colour) indicating settled regions with minimal star formation



Pair Galaxy Observations

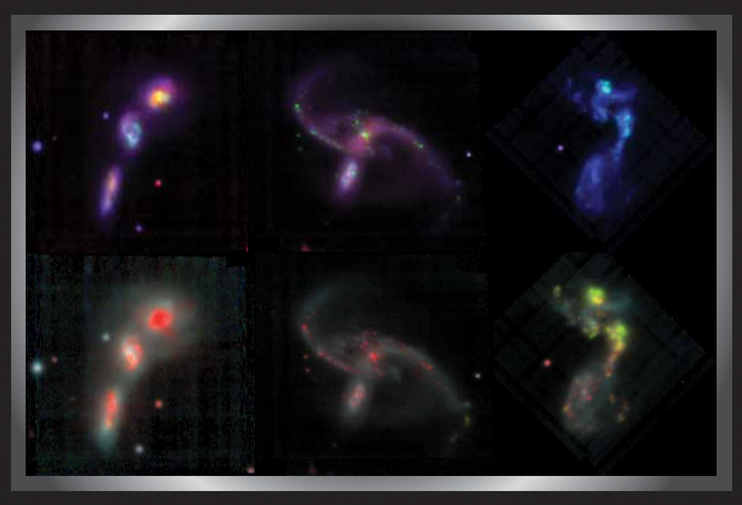
RGB:
- Distinctly separate shapes
- Galaxies separated by a distance
- Distinctly separate nuclei present in each galaxy

Emission:
- Patchy bursts of H-alpha, predominantly where interaction has occurred with pair
- Some potential AGN activity in nuclei

Merger Galaxy Observations

RGB:
- Distinctly odd shapes
- Linked by tidal tails
- Multiple nuclei, sometimes close together, sometimes separated by a distance

Emission:
- Stronger H-alpha through structures
- OIII emissions
- Signs of AGN activity in the nuclei



Post-Coalescence Galaxy Observations

RGB:
- A settled appearance
- One solid galaxy shape
- One single galactic nuclei

Emission:
- Comparatively lacking strong emissions
- Emission pockets mostly in the outer shell after merger gas expulsion

What's Next?

- Several images (shown) were sliced and exported to PixInsight for improved visual enhancement and analysis.
- Re-examining the redshift calculation and improving accuracy.
- Improving the colour analysis with (v - r) colour comparison.
- More detailed spectral analysis to determine any other correlations between stages of galaxy interaction and colour.

Bacon et al., SPIE 7735, 7 (2010)

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Pleiades Astrophoto 2024, PixInsight, 1.8.9-3 Ripley, Pleiades Astrophoto, <https://pixinsight.com>.

Husemann, B 2019, Program ID: 0103.A-0637(A).