Multi-wavelength study of the population of galaxies in intermediateredshift clusters: the case of RXJ1257+4738 at z = 0.9

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OUTLINE

- 1. INTRODUCTION
 - EVOLUTION IN GALAXY CLUSTERS
 - GLACE PROJECT
 - WORKING WITH TUNABLE FILTERS
- 2. CL0024+1654: THE TEST CASE
 - OBSERVATIONS
 - THE CATALOGUE
 - SF AND AGN POPULATION
 - DYNAMICS
- 3. RXJ1257+4738: THE TARGET CLUSTER
 - OBSERVATIONS
 - CLUSTER SAMPLE
 - FIR AND [OII] SAMPLES
 - STAR FORMATION ACTIVITY
 - MORPHOLOGY
- 4. CONCLUSIONS

CLUSTERS OF GALAXIES

Dark matter (85%) Hot gas (13%) Galaxies (2%)



GALAXY EVOLUTION IN CLUSTERS





The project aims to study the SF population in clusters...



... by exploiting the OSIRIS/GTC tunable filters (TF)

TUNABLE FILTERS: BASICS



TUNABLE FILTERS: CAVEATS





TUNABLE FILTERS: DATA REDUCTION

- 1. Basic reduction:
 - Bias and flat-field corrections, CR removal
 - Sky rings subtraction
 - Fringing correction
 - Image alignment
 - Image combination
 - Astrometry
 - Image degradation
- 2. Source extraction and photometry:
 - Detection in the deep image
 - Photometry on the degraded slices
- 3. Calibration:
 - Wavelength
 - Flux

TUNABLE FILTERS: DATA REDUCTION

- 1. Basic reduction:
 - Bias and flat-field corrections, CR removal
 - Sky rings subtraction
 - Fringing correction
 - Image alignment
 - Image combination **!!?**
 - Astrometry
 - Image degradation
- 2. Source extraction and photometry:
 - Detection in the *deep image*
 - Photometry on the degraded slices \rightarrow Building of pseudo-spectra
- 3. Calibration:
 - Wavelength $\rightarrow \lambda = \lambda_0 5.04r^2 + a_3(\lambda)r^3$
 - Flux !!?

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Cl0024+1654: THE TEST CASE



Cl0024+1654: Hα sample

210 ELGs detected:

- 174 robust cluster H α emitters
- 28 interlopers
- 8 unconfirmed

 $f_{H\alpha}$ -completeness ~ 0.9 x 10⁻¹⁶ erg s⁻¹ cm⁻²





Cloo24+1654: Ha Luminosity Function



CI0024+1654: SF AND AGN POPULATIONS

25 BLAGN

39 NLAGN



37% OF ELGS ARE AGN

Cl0024+1654: REDSHIFT DISTRIBUTION

We found the double-peaked redshift distribution (Moran+07 & Czoske+02):

- structure "A" (centred at z = 0.395, the main cluster)
- structure "B" (centred at z = 0.381, a l.o.s infalling group)



Cl0024+1654: CLUSTER DYNAMICS

Following Diaferio99 caustic technique implemented in the CausticApp code (Serra+11)...



...we obtained mass, radius and velocity dispersion compatible with previous results

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RXJ1257+4738: THE TARGET CLUSTER

BROAD-BAND IMAGING

OSIRIS/GTC (g'r'i'z') LIRIS/WHT (J) IRAC/Spitzer (3.6µm,5.8µm) IRAC/Spitzer (4.5µm,8µm) MIPS/Spitzer (24µm) PACS/Herschel (100µm,160µm) SPIRE/Herschel (250µm,350µm,500µm)

OSIRIS TF IMAGING

Total on-source exposure time = 18 hours Wavelength range = 6884 - 7104 Å Number of scan steps = 24 Space between scan steps = 10 Å TF FWHM = 20 Å

GMOS/GEMINI MOS

21 spectroscopic cluster members



Photometric cluster members using Monte Carlo simulations

1. Creating 600 mock catalogues varying each band flux

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Using Bruzual & Charlot (2003) templates

Photometric cluster members using Monte Carlo simulations

- 1. Creating 600 mock catalogues varying each band flux
- 2. SED-fitting the optical-to-NIR part with LePhare
- 3. Defining the initial cluster range by fitting a Gaussian



Photometric cluster members using Monte Carlo simulations

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- 4. Classifying each source using its simulated z_{PHOT} distribution



Photometric cluster members using Monte Carlo simulations

- 1. Creating 600 mock catalogues varying each band flux
- 2. SED-fitting the optical-to-NIR part with LePhare
- 3. Defining the cluster range by fitting a Gaussian
- 4. Classifying each source using its simulated Z_{PHOT} distribution
- 5. Obtaining the final sample defining the cluster range with the accuracy



 $\sigma_{\Delta z/(1+zSPEC)} \sim 0.094$

z_{PHOT} = [0.79, 0.98]

292 robust cluster candidates (including 21 spectroscopic sources)

RXJ1257+4738: THE FIR SAMPLE

Match the cluster sample with the MIR/FIR catalogues:
67 FIR-emitter candidates

RXJ1257+4738: THE FIR SAMPLE



1. Automatic classification using a S/N criterion:



- 1. Automatic classification using a S/N criterion
- 2. Visual inspection of each pseudo-spectrum



271 sources visually selected from the automatic catalogue of 1080

- 1. Automatic classification using a S/N criterion
- 2. Visual inspection of each pseudo-spectrum
- 3. Visual inspection of each TF source thumbnail



- 1. Automatic classification using a S/N criterion
- 2. Visual inspection of each pseudo-spectrum
- 3. Visual inspection of each TF source thumbnail
- 4. Colour-colour diagram to reject interlopers



118 [OII]-emitter cluster galaxies

- 1. Automatic classification using a S/N criterion
- 2. Visual inspection of each pseudo-spectrum
- 3. Visual inspection of each TF source thumbnail
- 4. Colour-colour diagram to reject interlopers
- 5. Radial velocity constraint



87 [OII]-emitters in the v_{Los} range full covered

315 robust cluster members

RXJ1257+4738: COLOUR, MASS & SFR



FIR and [OII] populations almost no overlap...

RXJ1257+4738: SF ACTIVITY

Centre of the main structure (A) quenched



but filamentary/group look, traced by SF galaxies

RXJ1257+4738: SF ACTIVITY



(average) SFR & sSFR show no clear dependence with the environment

RXJ1257+4738: SF ACTIVITY

As seen by the spatial distribution of SF galaxies...



... the fraction of [OII] and FIRemitters suggest that the intermediate density cluster environment is the preferred for the enhancement of the SF activity

RXJ1257+4738: MORPHOLOGY

Classification between **ET and LT** of **30%** of the cluster sample using **galSVM** (Huertas-Company+08), but...



...we observed a large fraction of **ET galaxies in the blue region!!!**



Physical properties distributions show no remarkable differences among the three morphological types...



RXJ1257+4738: MORPHOLOGY



Are the "blue" ETs...

- ... incorrect classified (morph, z)?
- ... peculiar galaxies?
- ... AGNs?
- ... ET with recent star formation? ... LCBGs?



RXJ1257+4738: MORPHOLOGY



Mild morphology-density and morphology-radius relations

CONCLUSIONS (I)

This work aimed to achieve two main goals: to prove the usefulness of the TFs to study ELGs in galaxy clusters, and to make a complete study of an intermediate-redshift galaxy cluster.

The first objective was completed performing an $H\alpha/[NII]$ survey of the Cl0024+1654 cluster at z=0.395, and the main results are:

- With the catalogue of 174 robust H α cluster emitters we improved the initial GLACE requirements achieving a SFR completeness of ~ 0.9 M $_{\circ}$ /yr.
- The technique allowed us to deblend the H α and [NII] lines and, therefore, to discriminate the AGN population.
- Our redshift estimation of spectroscopic quality allowed us to identify two cluster structures (the main cluster and an infalling group in the l.o.s)
- The radial velocities of our ELGs allowed us to estimate the mass, radius, and velocity dispersion of the cluster by using the caustic technique (Diaferio99). The results are in very good agreement with previous weaklensing estimations.

These results indicate that the TF tomography technique is adequate for the GLACE research purposes.

CONCLUSIONS (II)

The second goal was performed as a multi-wavelength study of the RXJ1257+4738 cluster at z=0.866, including the study of the star formation activity through the FIR and [OII] emitters samples, and a partial morphological characterization of the cluster members. The main results are:

- We built a cluster catalogue of 315 reliable cluster members, including 38 FIR-emitters and 87 [OII]-emitters.
- The structures of the cluster density map with a filamentary-like look, also traced by the SF galaxies spatial distribution, suggests that the cluster is still under the process of formation.
- No correlation was found between the SFR and the local density, indicating that the average SF galaxy forms the same stellar mass per time unit in all local density environments.
- A dependency is found when analysing the number of emitters respect to the total of cluster members: the fraction of emitters significantly grows from low- to intermediate-density regions, and even the number of [OII]- emitters in the highest densities is not negligible.
- We were able to morphologically classify 30% of the cluster sample using ground-based observations. We reproduced a mild morphology-density relation, and found that a blue ET sample is the dominant population.

AND THAT'S ALL ... THANK YOU FOR YOUR TIME!!

EXTRA: [OII] VS FIR

