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JELLYFISH GALAXIES IN MACS J0717.5+3745 AND THEIR LINK TO THE COSMIC WEB

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Abstract. Galaxies in clusters undergo several phenomena, such as ram pressure stripping and tidal interactions, that can trigger or quench their star formation, and, in some cases, lead to galaxies acquiring unusual shapes and long tails, such as jellyfish galaxies. We searched for such objects in MACS J0717.5+3745, for which our large spatial coverage and abundant sampling of spectroscopic redshifts allowed us to pursue a detailed analysis in the cluster and its extended filament. We found 81 jellyfish galaxy candidates in a large region around MACS0717, that tend to avoid the densest regions of the cluster. An eight-magnitude optical and infrared catalogue covering the entire region allowed us to compute the best stellar population fits with LePhare through the GAZPAR interface for 79 jellyfish galaxies and for a control sample of 122 non-jellyfish galaxies. We find stellar masses in the range $10^9 - 10^{11}$ $M_\odot$, rather young stellar ages (more than half have an age smaller than 1.5×10^9 yrs), star formation rates (SFRs) in the $10^{-1} - 60$ $M_\odot$ yr^{-1} range and rather high specific star formation rates (sSFRs), with more than half of the sample having values larger than 10^{-9} yr^{-1}. The mean sSFR of the 79 jellyfish galaxy candidates is 3.2 times larger than that of star-forming non-jellyfish galaxies. Based on several arguments, the jellyfish candidates identified in MACS0717 seem to have fallen rather recently into the cluster.

Keywords: galaxy clusters, jellyfish galaxies

1 Introduction

Galaxies in clusters may be undergoing several phenomena, among which ram pressure stripping due to their interaction with the hot intracluster gas. Their gas may then be compressed and undergo intense star formation, in the galaxy itself as well as in filaments that can be stripped from them. They thus can acquire the shape of a jellyfish and their study can give indications on the cluster properties.

In our search for extensions and filaments around clusters of the DAFT/FADA and CLASH surveys, we have selected red sequence galaxies and drawn density maps (Durret et al. 2016). For the cluster MACS J0717.5+3745 (hereafter MACS0717) at redshift z=0.5458, we detected a very large extension covering 6.0×1.8 Mpc^2 including the cluster, and continued by a 3.2×2.1 Mpc^2 filament North-South extension. These extensions are in rough agreement with those found with a weak lensing analysis by Jauzac et al. (2012) and Martinet et al. (2016).

We exploit here a large set of spectroscopic and photometric data to search for jellyfish galaxies in MACS0717 and its extended filament, and to characterise their properties.

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2 Spatial distribution of jellyfish galaxies in MACS0717

2.1 The data

Our study is based on a large mosaic covering the entire cluster and its extended filament in the F606W and F814W filters. We also have a catalogue of over 600 spectroscopic redshifts, and a ground-based 8 magnitude catalogue in the optical and infrared that allows a stellar population analysis.

2.2 Selection of jellyfish candidates

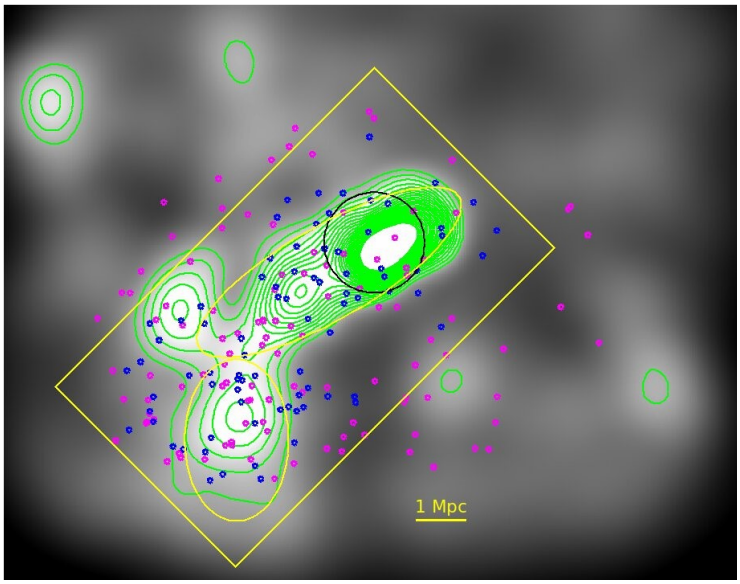

Fig. 1. Density map of red sequence galaxies from Durret et al. (2016), with green contours starting at 3σ above the background and spaced by 1σ. The black circle has a 1 Mpc radius around the cluster centre, the two yellow ellipses indicate the maximum extensions of the cluster (6.0×1.8 Mpc^2) and its filament (3.2×2.1 Mpc^2). The blue and pink points respectively show the positions of the jellyfish and non-jellyfish galaxies considered in the stellar population analysis.

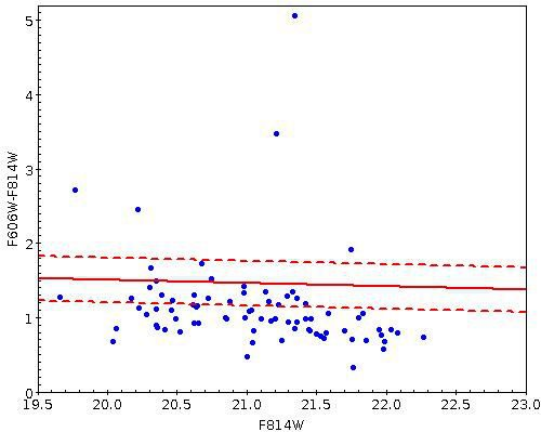

Fig. 2. F606W-F814W vs. F814W colour-magnitude diagram. The red line is the best fit to the red sequence, and the red dashed lines indicate the interval of ± 0.3 on either side of this line, in which red sequence galaxies were selected to build the density map shown in Fig. 1. The 81 jellyfish candidates are shown as blue points.

We looked at all the galaxies with a redshift within $\pm 4\sigma_v$ of the cluster redshift (σ_v being the cluster velocity dispersion). We eliminated galaxies with obvious gravitational interactions with a neighbour (within 50 kpc) and two of us selected jellyfish candidates by eye, classifying them between J=1 (least probable) and J=5 (most probable), following the classification proposed by Ebeling et al. (2014). Our catalogue of jellyfish candidates contains 81 galaxies. Their spatial distribution is shown in Fig. 1. We can note that the jellyfish tend to avoid the cluster centre and are spread over the entire region. In the colour-magnitude diagram that was used to select the red sequence galaxies used to build the density map, a large majority of the jellyfish galaxies are below the red sequence, confirming that they are mainly blue galaxies, as expected (see Fig.2).

3 Stellar populations

For 79 of the 81 jellyfish galaxies of MACS0717 we were able to obtain a stellar population fit with the LePhare software through the GAZPAR interface. A comparable fit was obtained for 122 non-jellyfish galaxies in the same redshift range as a control sample.

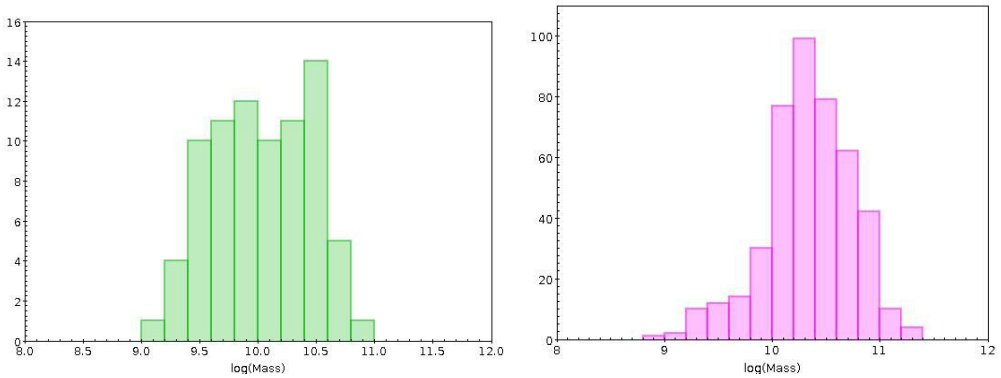

Fig. 3. Histograms of the galaxy stellar masses in jellyfish (left) and non-jellyfish (right) galaxies.

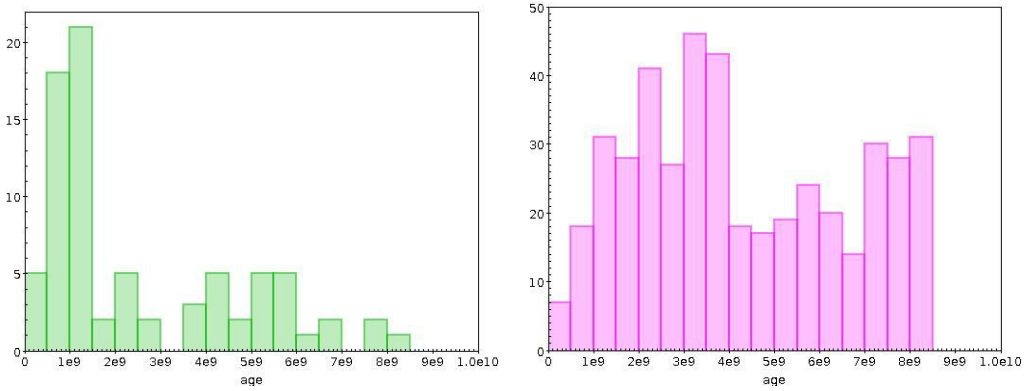

Fig. 4. Histograms of the galaxy stellar ages in jellyfish (left) and non-jellyfish (right) galaxies.

The histograms of the stellar masses, ages, star formation rates and specific star formation rates are shown in Figs. 3, 4, 5, and 6 respectively.

4 Main results and conclusions

Out of more than 600 galaxies with spectroscopic redshifts, we have found 81 jellyfish candidates.

The analysis of the stellar populations of 79 of these show that the best fit spectrum of all but two shows the Hα line, and more than half are fit with a spectrum that also includes the [OII]3727, Hβ, and [OIII]4959,5007 emission lines, in agreement with the general picture of jellyfish undergoing star formation. This is confirmed by the main quantities derived from the stellar population fits: the jellyfish galaxies have stellar masses in the

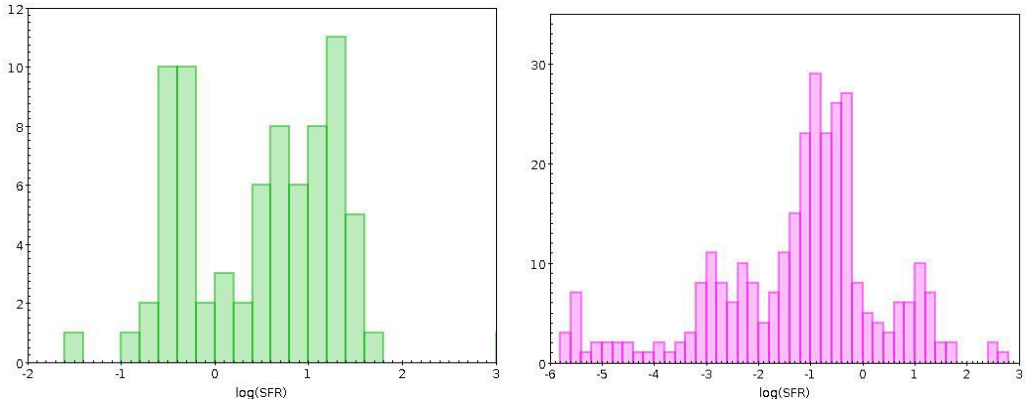

Fig. 5. Histograms of the galaxy star formation rates in jellyfish (left) and non-jellyfish (right) galaxies.

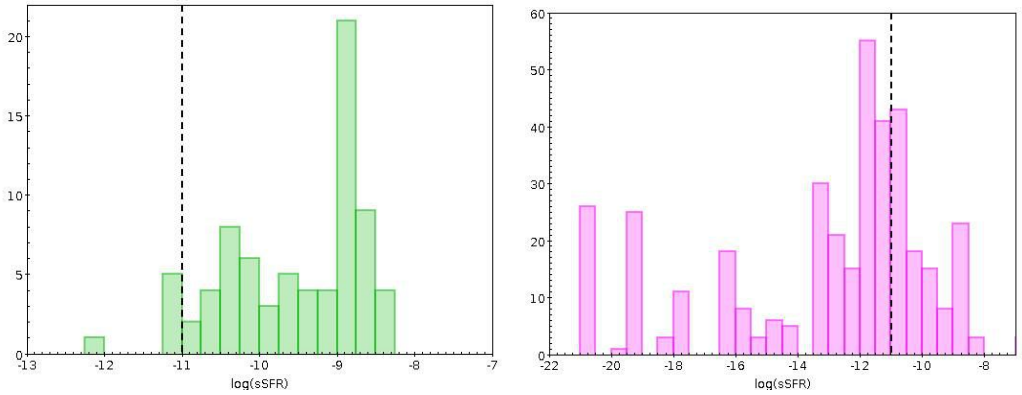

Fig. 6. Histograms of the galaxy specific star formation rates in jellyfish (left) and non-jellyfish (right) galaxies.

range $10^9 - 10^{11}$ $M_\odot$, rather young stellar ages (more than half have an age smaller than 1.5×10^9 yrs), star formation rates (SFRs) in the $10^{-1} - 60$ $M_\odot$ yr^{-1} range and quite high specific star formation rates (sSFRs), with more than half of the sample having values larger than 10^{-9} yr^{-1}. The mean sSFR of the 79 jellyfish galaxy candidates is 3.2 times larger than that of non-jellyfish galaxies.

We are now in the process of analysing the dynamical properties of the jellyfish galaxies in MACS0717 compared to the overall cluster dynamics, based on a plot as that of Mahajan et al. (2011), Figure 10. The result of this analysis, coupled with a comparable study for another cluster for which we have similar data, will be described in a forthcoming paper (Durret et al., in preparation).

A full description of the present work on MACS0717, together with the detection of 97 jellyfish candidates in 22 clusters covering the redshift range $0.2 < z < 0.9$ and the analysis of the stellar populations of 31 of them can be found in Durret et al. (2021).

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