X-ray and optical substructuring of the DAFT/FADA survey clusters

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The DAFT/FADA survey

This survey is based on a rich data base for 91 medium redshift (0.4 < z < 0.9) massive clusters (mass larger than 2 x 10^{14} M_{sol}) with Hubble Space Telescope imaging available.

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The aims of this survey are twofold:

• Build a large database of deep imaging data on these clusters to analyse the properties of clusters in this redshift range and tie the optical and X-ray substructure growth with redshift over timescales of about 2.5 Gyrs
• Obtain constraints on dark energy

We present here the morphological properties of the subsample of clusters with XMM-Newton data.

Searching for optical substructures

For each cluster with more than 20 galaxy redshifts available in the cluster range, we applied the Serna & Gerbal (1996, A&A 309, 65) analysis to search for substructures. A dendogram is created, roughly representing the binding potential energy between galaxies (Fig. 3).

The number of substructures and the corresponding masses can thus be estimated (see examples for three clusters in Table 2).

Acknowledgements.

This paper is based on optical data obtained at various observatories/telescopes: ESO, Gemini, SOAR, WHT, TNG, Blanco, and archive data from ESO, EHT, and Subaru were also retrieved. We also acknowledge the use of the XMM-Newton and Chandra archives.

The data

We retrieved archive XMM-Newton data of sufficient quality for 30 clusters (see full list in Table 1).

We obtained deep optical imaging for most of the 91 clusters in several bands, with various telescopes, totalling about 70 nights of 4m telescope time, plus some archive data.

We retrieved all the galaxy redshifts available in NED in a 5 arcmin region around the cluster center, and have added some redshifts obtained during several observing runs with 8m telescopes.

The X-ray analysis

The XMM-Newton data were analysed in the usual way. The X-ray images (in majority those obtained with the pn, in some cases MOS1) were then fit with an azimuthally symmetric elliptical model.

The residuals were computed as the difference between the image and the fit (see Fig. 1).

Results

• The studied clusters extend to z=0.9 the L$_X$-T$_X$ relation established by Takey et al. (2011, A&A 534, A120) for clusters at z<0.6
• Out of 23 spatially analysed clusters, 6 have obvious substructures, 13 have possible substructures and 4 have no substructures in X-rays
• Based on comparison with simulations, there is work to be done to explain why there is apparently little X-ray luminosity evolution even though the cluster gravitational potentials are clearly evolving with time (see e.g. Ehlert & Ulmer 2009, A&A 503, 35)

Fig. 1. XMM-Newton image (left), model (middle) and residuals (right) for Cl0016+1609.

Fig. 2. Left: residual X-ray image of the merging cluster Cl0152.7-1357 at z=0.8310, the two components are circled in yellow, the other sources are AGN unrelated to the cluster. Right: redshift histogram for the 115 galaxies in the cluster redshift range, the three main structures indicated in blue, green and red, colour coded as in Fig. 3, and slightly displaced to make them more visible.