Substructures in DAFT/FADA survey clusters based on XMM-Newton and optical data

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The DAFT/FADA survey

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- Sample of 91 clusters with:
  - Medium-high redshift ($0.4<z<0.9$)
  - High masses ($M>2x10^{14}M_{sol}$)
  - HST data
- And for most of them:
  - 4m ground based BVRIZJ follow up
  - good spectroscopy (Nz>15)
- And X-ray data (XMM or Chandra) for half of them.

- 1st goal: Studying a large homogeneous sample of high redshift massive clusters
- 2nd goal: Getting DE constraints through WL tomography. (Need for a good PSF correction and accurate photometric redshifts)

The data (proprietary and archival)

XMM-Newton data for 32 clusters (and Chandra data for a few clusters)
Deep multi-band optical images → photometric redshifts (LePhare software)
Optical spectroscopy : 29 clusters with at least 15 spectroscopic cluster members (18 clusters with X-ray data and 11 clusters with no X-ray data)

Searching for substructures

➢ In X-rays

X-ray luminosities were derived for 32 clusters and X-ray temperatures for 25 clusters
For 23 clusters, the emissivity was fit by a β–model and subtracted to the image, and results were assessed with simulations

➢ In the optical

For all the clusters with at least 15 spectroscopic members, we applied the Serna & Gerbal (1996) dendogram hierarchical clustering method

Results and discussion:

➢ For 10 subclusters detected both in X-rays and in the optical, the substructure to total cluster X-ray flux ratio remains more or less constant with redshift: 5% – 15% (similar to value found in simulations at z=0 by Gao et al. 2012, see Fig. 4)

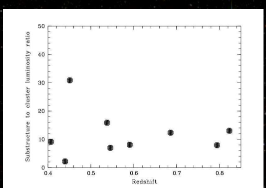

Fig. 4. Ratio of the substructure mass to the total cluster mass for the 10 clusters with a substructure detected both in X-rays and in the optical

➢ Comparison with isolated groups observed by Connelly et al. (2012, ApJ 756, 139) shows that our clusters are brighter in X-rays

➢ X-ray emission probably triggered by merging of infalling groups

➢ Comparison with simulations by Poole et al. (2007) gives time needed for substructures to disappear (Fig. 5)

➢ Most of the X-ray substructures detected are at their first cluster pericenter approach and have fallen in quite recently

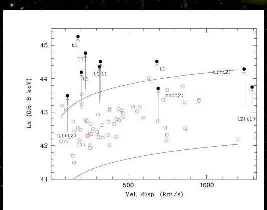

Fig. 5. X-ray luminosity as a function of cluster or substructure velocity dispersion. Open circles are groups from Connelly et al. (2012), the two black curves show the 3σ envelope of the Connelly X-ray selected sample. The black filled circles are our detected substructures. The lower extremities of the vertical lines show the places of the infalling structures prior to their dynamical capture.

Results for three clusters

Abell 851, a cluster with several substructures at z=0.049

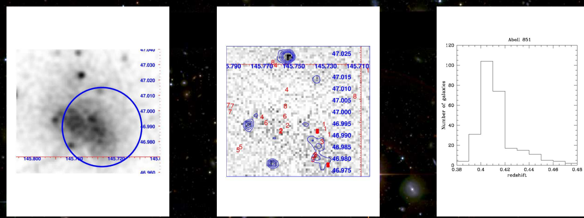

Fig. 1. Abell 851. Left: XMM image, with the blue circle showing a 500 kpc radius. Middle: zoom on the substructures detected after subtracting a –model. Right: histogram of the 213 spectroscopic redshifts close to the cluster redshift. .

GHO 1602+4312 a cluster with no major substructures at z=0.895

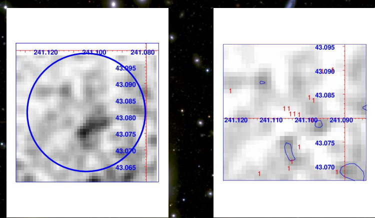

Fig. 2. Same as Fig. 1 for the distant cluster GHO 1602+4312

MS 1054-03 a cluster with a substructure at z=0.826

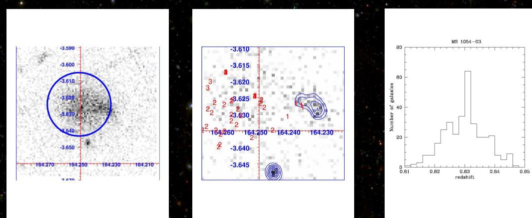

Fig. 3. Same as Fig. 1 for the distant cluster MS 1054-03 (326 spectroscopic redshifts)

Conclusions

- The percentage of mass in substructures does not seem to vary with redshift between z=0.4 and z=0.9, and is 5%-15%, in agreement with CDM and simulations
- Most of the X-ray substructures detected are at their first cluster pericenter approach and have fallen in quite recently
- Infall of material on to clusters is not isotropic, so avoid any hypothesis of spherical symmetry (such as computing galaxy luminosity functions in concentric rings)

References

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Gao et al. 2012, MNRAS 425, 2169
Poole et al. 2007, MNRAS 380, 437

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