Merger events with galaxy-gas separation in the hot galaxy cluster A2163.

H. Bourdin

- Università di Roma “Tor Vergata”

P. Mazzotta, R. Martino

- Università di Roma “Tor Vergata”

M. Arnaud, J.-L. Sauvageot, G.W. Pratt

- CEA, Saclay

S. Maurogordato, A. Cappi, C. Ferrari, C. Benoist

- OCA, Nice
Merger events with galaxy-gas separation in the hot galaxy cluster A2163.

- Introduction: the hottest Abell galaxy cluster
- Cluster structure and dynamics from X-ray observations
- Evidencing a new “bullet cluster”
A2163: the hottest Abell galaxy cluster

- A rich and exceptionally bright and hot galaxy cluster ($L_x = 4.10^{38}$ W, $<kT> \sim 12-14$ keV, Arnaud et al., 92)

- Major merger evidences:
  - The brightest radio halo (Feretti et al., 01, 04)
  - Irregular morphology of ICM, galaxy and DM

- Large dispersion between mass estimates from X-ray (e.g. Elbaz et al., 95, Markevitch et al., 96) and weak lensing analyses (e.g. Cypriano et al., 94; Radovich et al., 08)

- A possible candidate for non thermal hard X-ray emission (Rephaeli et al. 06; Million & Allen, 09)

- A favoured target for SZ observations (e.g. Wilbanks et al, 94; Holzapfel et al, 97; Lamarre et al, 08; Nord et al, 09)
A2163: galaxy and dark matter morphology

- A complex galaxy density distribution (Maurogordato et al., 08)
  - Two sub-clusters (A2163 a-b)
  - A bimodal density distribution in the central region, with two BCGs
- An E-W elongated DM morphology (Radovich et al., 08)
A2163: The hottest Abell galaxy cluster

A2163: ICM morphology and thermal structure

X-ray: ROSAT-PSPC
Elbaz et al., 95

X-ray: Chandra-ACIS
Owers et al., 09

X-ray: Chandra-ACIS
Radio: VLA-20 cm
Govoni et al., 04; Feretti et al., 01
A2163: Structure and dynamics from X-ray observations

- **Spectral background modelling:**
  - Soft excess emission from North Polar Spur (kT~ .3 keV)

- **Neutral hydrogen absorption:**
  - Cluster location near the Galactic Plane (l=19º,b=37º): => High average Nh (Nh~15.10^{24} m^{-2})
  - Fluctuations of the IR flux (~20% across the field of view)

XMM-EPIC: 5*15 ks

Chandra-ACIS: 72 ks

IRAS, 100 µ m

\( \delta \tau / \tau \sim 20\% \)
A2163: Structure and dynamics from X-ray observations

**ICM brightness: Chandra-ACIS**

**Galaxies: 2.2m/WFI**

**A2163: X-ray morphology**

- **At large scale**
  - E-W elongated
  - Asymmetric morphology (eastern extension)

- **In the central region (wavelet analysis; high resolution details; a<2arcmin)**
  - Eastern brightness peak close to BCG1
  - Western core delimited by a sharp edge with bow shape

**X-ray brightness peak**

**Western core**
A crossing cool core separated from galaxies

- The cool core is delimited westwards by a cold front and preceeded by a galaxy subcluster

- Colours: ICM temperature map (wavelet spectral-imaging, XMM-EPIC)
- Black iso-contours: High resolution details in the gas structure (wavelet analysis, Chandra-ACIS)
- White contours: Galaxy iso-density
ICM density, temperature excess in the outskirts of the eastern cluster sector

Possible shock heating of the cluster atmosphere behind the accreted cool core

Scaled profiles ($P/P_{500}$):

- The western + overall profile follow universal trend of a representative sample of nearby clusters (RECESS, Arnaud et al, 09)
- The eastern profile is shallower to the centre, as expected for a morphologically disturbed cluster
Mass measurements

- **A2163 mass, Yx proxy:**
  - $M_{500,Yx} = (18.7\pm2.0)\times10^{14}M_\odot$
  - A very massive cluster, consistent with recent galaxy velocities and weak lensing analyses.

- **A2163 mass, Hydrostatic Equilibrium (HE):**
  - $M_{500,HE} = (24.7\pm.5)\times10^{14}M_\odot$
  - ==> Possible departure from HE in the eastern cluster sector, hence in the overall cluster atmosphere
  - $M_{500,HE,West} = (14.5\pm.5)\times10^{14}M_\odot$
  - ==> Western mass profile testifying to the cluster dynamical state prior to the merger event?
  - ==> Mass ratio of the sub-cluster accretion $\sim 1:3$
The northern sub-cluster A2163-b

- Mass profile assuming HE:
  - $M_{500} = (2.1 \pm 0.1) \times 10^{14} M_\odot (f_{\text{gas}} \sim .1)$

- Interaction with A2163-a
  - $\Sigma_x$ and kT maps: no interaction evidence within r500

- 2 body dynamical analysis (gal. velocities, Beers et al., 82):
  - Recent post-merger (t<.2 Gyr) excluded
  - Pre-merger allowed @ high projection angle (r~10 Mpc)
A2163 and the “bullet cluster”

- **Similarities**
  - Merger scenario: “bullet” morphology and temperature, projected galaxy-gas separation (130 vs. 100 kpc) => supersonic sub-cluster accretion
  - Extremely hot and luminous clusters
  - Luminous and extended radio-haloes

- **Differences (A2163 vs. 1E65756)**
  - Lower Projected distance between the two components
    - The “bullet” appears as embedded in a denser cluster atmosphere

Evidencing a new "bullet cluster"
A2163 and the “bullet cluster”

- **Similarities**
  - **Merger scenario:** “bullet” morphology and temperature, projected galaxy-gas separation (130 vs. 100 kpc)
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  - **Extremely hot and luminous clusters**
  - **Luminous and extended radio-haloes**

- **Differences (A2163 vs. 1E65756)**
  - **Lower Projected distance between the two components**
    - The “bullet” appears as embedded in a denser cluster atmosphere
  - **Possible higher projection angle in the case of A2163:**
    - No visible shock front

Evidencing a new "bullet cluster"
Conclusions

- **Cluster centre strongly disturbed by a recent sub-cluster accretion**
  - A cool core delimited by a sharp edge, located close to a secondary galaxy over-density ==> Fast crossing of a galaxy sub-cluster, galaxy-gas separation

- **Pressure excess and departure from HE backwards the moving sub-cluster**
  - Supersonic sub-cluster accretion
  - Assuming HE in the eastern cluster side: merger mass-ratio of ~ 1:3

- **Overall cluster mass** $M_{500,Yx}(r) = (18.7 \pm 2).10^{14} M_\odot$
  - A very massive cluster; consistent with recent estimates from weak lensing, SZ and optical analyses

- **Similarities with 1E65756** (merger scenarios, hot and luminous clusters with powerful radio haloes) / possible differences in merger age and geometry