THE 2009 X-RAY VIEW OF GALAXY GROUPS: MASS, ENTROPY AND AGN FEEDBACK IN GALAXY GROUPS

FABIO GASTALDELLO
IASF MILANO, UCI

OUTLINE

3. MASS PROFILES FOR A SAMPLE OF X-RAY BRIGHT AND RELAXED GROUPS

4. ENTROPY PROFILES FOR THE SAME SAMPLE. RELEVANT SCALE FOR BREAKDOWN OF SELF-SIMILARITY

5. AGN FEEDBACK IN TWO INTERESTING OBJECTS
A SPECIAL ERA IN X-RAY ASTRONOMY

Chandra

• 1 arcsec resolution

XMM-Newton

• High sensitivity due to high effective area, i.e. more photons

SUZAKU

• Low and stable background
Clusters X-ray results

Pointecouteau et al. 2005

Vikhlinin et al. 2006

• NFW a good fit to the mass profile

• c-M relation is consistent with no variation in c and with the gentle decline with increasing M expected from CDM ($\alpha = -0.04 \pm 0.03$, P05).
THE PROJECT

• Improve significantly the constraints on mass profiles and c-M relation by analyzing a wider mass range with many more systems, in particular obtaining accurate mass constraints on relaxed systems with $10^{12} \leq M \leq 10^{14} \, M_{\text{sun}}$

• There were very few constraints on groups scale ($10^{13} \leq M \leq 10^{14} \, M_{\text{sun}}$)

• In Gastaldello et al. 2007 we selected a sample of 16 objects in the 1-3 keV range from the XMM and Chandra archives with the best available data
• After accounting for the mass of the hot gas, NFW + stars is the best fit model

**RESULTS**
RESULTS

• No detection of stellar mass due to poor sampling in the inner 20 kpc or localized AGN disturbance.

Buote et al. 2002

NGC 5044
We obtain a slope $\alpha = -0.226 \pm 0.076$, $c$ decreases with $M$ at the $3\sigma$ level. When clusters added $c$ decreases with $M$ at the $6.7\sigma$ level (Buote+07)
GAS FRACTIONS

GASTALDELLO ET AL. 2007 (see also Sun+09)
Entropy profiles for groups $M_{\text{vir}} < 10^{14}$ solar masses

- Entropy (keV cm$^{-2}$)

- Radius (kpc)

- NGC 1550
- NGC 2563
- RGH 80
- NGC 533
- MKW 4
- IC 1808
- NGC 5129
- NGC 4325
- NGC 5044
Entropy profiles for clusters $M_{\text{vir}} > 10^{14}$ solar masses.
COMPARISON WITH MASSIVE CLUSTERS AND GRAVITATIONAL SIMULATIONS

(see also Sun+09)
LARGER RADII WITH SUZAKU

Abell 262: SATO, MATSUSHITA & FG 09

A 262

NGC 1550

ratio

1

0.9

Radius (kpc)

Ratio

T (keV)

1.4

1.2

1

Radius (kpc)

0

100

200

300
AGN FEEDBACK IN GROUPS

“UNFORTUNATELY, AGN HEATING IS NOT AS WELL STUDIED IN GROUPS AS IN CLUSTERS” (McNamara & Nulsen, ARAA). THIS IS RAPIDLY CHANGING (SEE NEXT TALKS).

NGC 5044 IS BRIGHT AND NEARBY (z=0.009), THE PERSEUS OF GROUPS. IDEAL TARGET TO STUDY AGN FEEDBACK.

AWM4 IS A CHALLENGE FOR THE IDEA OF AN AGN FEEDBACK LOOP
AWM4 AND AGN FEEDBACK

Gastaldello+08, see also O’Sullivan+05, Giacintucci+08
It's also a fossil system (Zibetti+08)

Gastaldello+08
AWM4 AND AGN FEEDBACK

Cavagnolo+08
EVERY RADIO BCG HAS A COOL CORE

Sun+09
X-RAY CORONAE

Abell 3627

Sun+09
AWM4 AND AGN FEEDBACK

Sun+09

Gastaldello+08
COLD FRONTS IN CLUSTERS

IN MERGING CLUSTERS

IN RELAXED CLUSTERS

Markevitch & Vikhlinin 07
COLD FRONTS IN CLUSTERS

Ascasibar & Markevitch 06
COLD FRONTS IN CLUSTERS

Markevitch & Vikhlinin 07
HOW ABOUT GROUPS?

EXAMPLES IN MERGING SYSTEMS, e.g. NGC 1404 IN FORNAX (Machacek+05)
NGC 5044

Gastaldello+09
COLD FRONTS IN NGC 5044

MENDEL+08 STUDY OF 111 MEMBERS:

PECULIAR VELOCITY OF 150 km/s WRT THE MEAN VELOCITY
COLD FRONTS IN NGC 5044

DETECTION OF A SUBSTRUCTURE (99.9 %) AT 1.4 Mpc
MENDEL+08
SUMMARY

• Detailed mass profiles for a sample of X-ray bright groups are well fitted by NFW+stars. Gas fractions are lower and with more scatter compared to clusters. Comparable quality with clusters, we can go out to $R_{500}$.

• Broken power law behavior of entropy profiles points to more important local modifications (AGN).

• AGN feedback in groups extremely interesting and it is starting to be investigated with high quality data. Sloshing cold fronts seem a rather common feature of cool cores, we are starting to see them also in groups (NGC 5098, aka RGH 80, Randall+09).