

Clusters of Galaxies

Principal Investigators at IRA

G. Brunetti, L. Feretti, I.M. Gioia, M. Murgia (OACa), T. Venturi, A. Zanichelli

Traditional field of research of IRA since the early 80's

Scientific Aims and Crucial Open Questions

Intracluster gas – How does it evolve with cosmic time?

Non-thermal components in clusters

Which is the origin of the non-thermal components?

How are these components related to the cluster dynamics?

How is the physics of the intracluster gas affected by the non-thermal components?

Dumb-bell galaxies in nearby clusters – Dynamics and fuelling of the radio emission?

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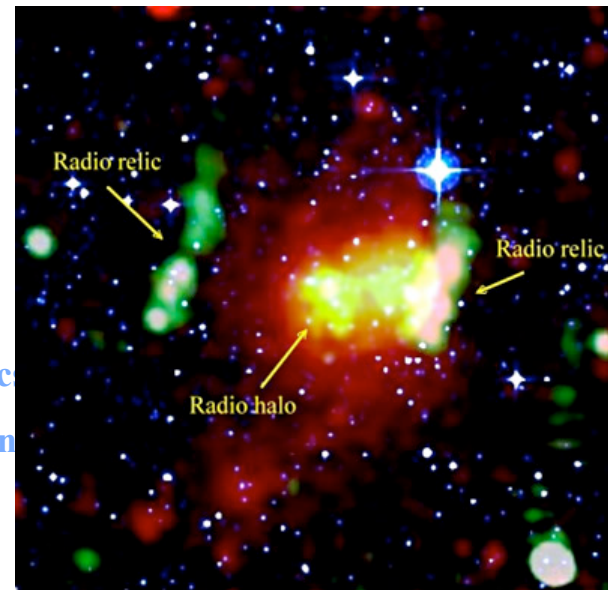
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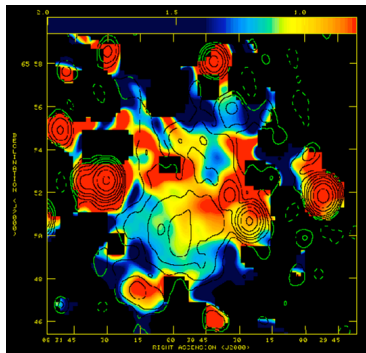
Non thermal radio emission in galaxy clusters

Observations – Studies (radio-optical-X) of individual clusters & GMRT radio halo cluster survey -About 50% of halos and relics known have been discovered and studied at IRA

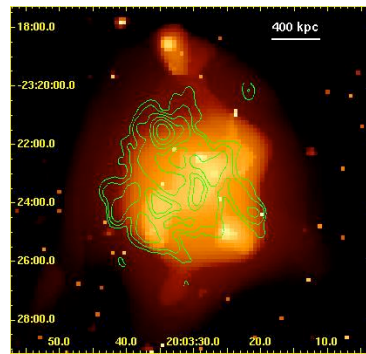
Theory –Origin of halos and relics -Re-acceleration model (injection of turbulence in the cluster volume during merging events) developed at IRA - Numerical simulations & statistics on the occurrence of radio halos

Magnetic fields – observations & simulations

Highlights – Cluster Centres

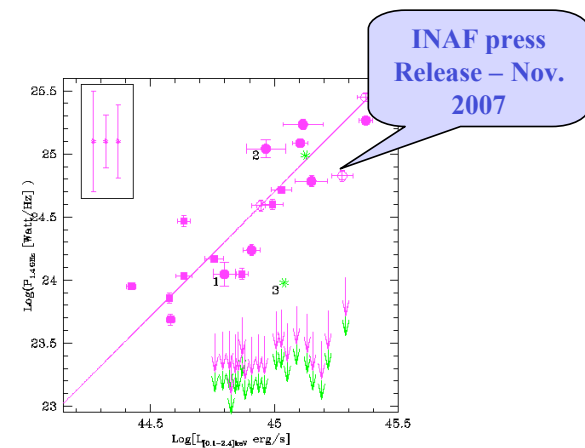


A665 – Feretti et al 2004

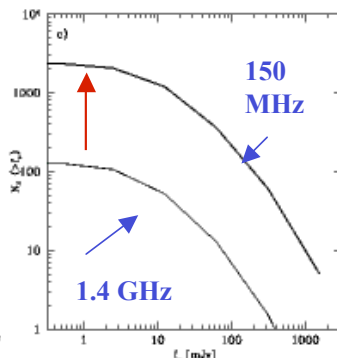
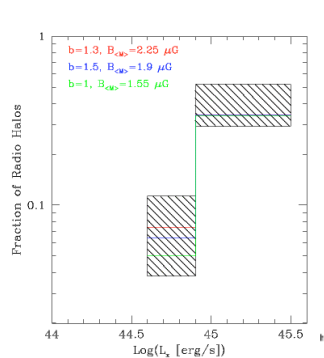


GMRT RadioHalo Survey

Venturi et al. 2007



Brunetti et al. 2007



Cassano et al. 2006 & 2007

3 PhD Projects in the period 2004-2006

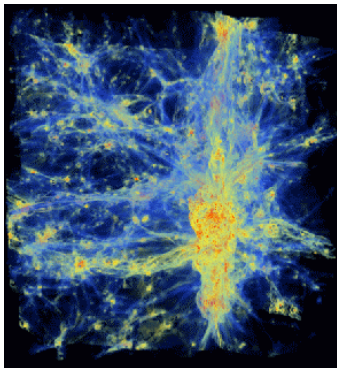
Cassano – RH statistics; Giacintucci – Multiband studies of merging clusters; Orru – Very low frequency studies of clusters of galaxies

Non thermal radio emission in galaxy clusters

Observations – Studies of individual cluster relics

Theory –Origin of relics –Turbulence through mergers - Numerical simulations

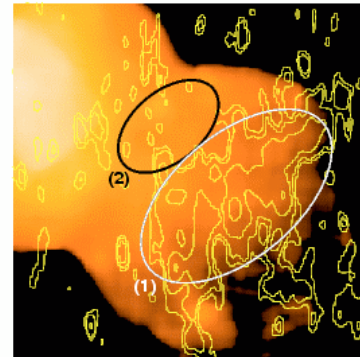
Highlights – Cluster Outskirts



Turbulence shock waves in simulated clusters – Energy of shock waves

Vazza et al. *subm.*

Phd 2006-2008

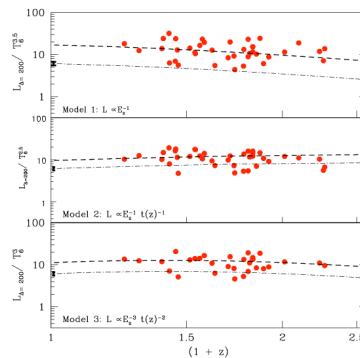
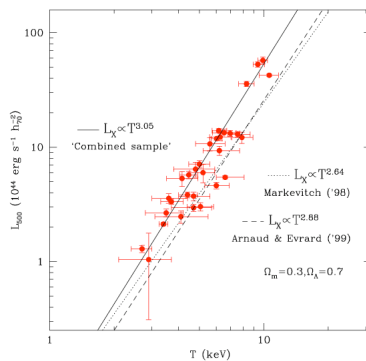


Coma cluster

Feretti et al. 2004

Highlights – L_X-T relation in clusters

Contribution of discrete sources to the X-ray emission of the ICM; two-step evolution of the cluster L_X-T relation with redshift – Deviation from self-similar evolution



1 PhD in 2003 – 2005 Branchesi

Branchesi et al. 2007a, 2007b

Access to international facilities (~from 2004) after approval of proposals

Computational time: 100000 hours with cluster LINUX 1024 cpus and SP5 512 cpus

Bulk of radio observations: ~250 hr VLA, ~ 200 hr WSRT , ~200 hr GMRT

Bulk of X-ray observations: Chandra & XMM ~ 400 ks

**Optical observations: ESO-NTT 3 nights
VLT-VIMOS IFU**

Future perspectives

Work in progress \longrightarrow follow up (observations, theory & numerical simulations)

Low frequency radio observations (surveys) of clusters to further test the prediction of the reacceleration model & statistics (low GMRT frequencies & LOFAR)

Multiband studies of individual clusters in existing samples and at high z

XMM observations of a large sample of clusters (64 , $0.02 < z < 0.8$)

mm observations of cD galaxies to study the molecular gas

International relevance of the research

Since 2004

40 refereed articles + **2** review papers + **1** book

30 published conference proceedings

16 invited talks at international workshops/conferences

Representation in **SOC** of **5** international meetings

Full organisation of **1** international meeting in Bologna (Cosmic Magnetism)

Magnetism as SKA Science Key Project

Main International Collaborations

MPA (Garching); ASTRON (Dwingeloo); Lebedev Institute (Moscow); NRL (Washington);

NRAO (Socorro); NCRA-GMRT (Pune); Univ. of Wisconsin (Madison);

Univ. of Michigan (Ann Arbor)

IRA people in the clusters of galaxies group

Staff	5	Brunetti G., Feretti L. , Gioia I.M. , Venturi T., Zanichelli A.
PostDocs	3	Branchesi M., Cassano R., Giacintucci S. (all at IRA)
	1	Orru' E. (at Innsbruck)
PhD	2	Vazza F. (INAF-IRA), Bonafede A. (external fundings)

and

2 Close collaborators INAF-OACa Govoni & Murgia (See presentation on Thursday)

6 Collaborators University of Bologna Dallacasa D., Fanti R., Fanti C., Giovannini G., Gregorini L., Setti G.

Recent sources of fundings

PRIN INAF (2005) PRIN MUR (2006)

Italian Space Agency (2005, 2006, 2007)

Italian Space Agency Moon Project (2006-2008)

Indo-Italian collaboration 2005-2007

~200 kEuro in the Group

Final considerations

Despite ...

- **International leadership of the group**
- **Success in obtaining external fundings**

The group ...

- **Is small**
- **Includes many non-staff people (Post Docs with average of positions 1 year)**
- **Difficult to maintain an adequate man power**