Metal Transport in Galaxy Clusters by AGN Outbursts

Fulai Guo (UC Santa Cruz)

* Reference: Guo & Mathews, 2010, ApJ, 717, 937

ISIMA Conference 07/09/2010

What are galaxy clusters?

As knots of the cosmic web, galaxy clusters are the largest gravitationally bound systems in the universe.



(Peterson & Fabian 2006)

DSS Optical

Chandra X-ray

This is a typical cool core cluster -- Abell 2029 in optical and X-ray wavebands.

Cluster baryons mainly reside in the hot, diffuse, intracluster medium (ICM)

Cluster Properties--Temperature Distribution







Cool-core clusters



Cluster Properties--Metal Distribution



De Grandi & Molendi 2001

Central Metallicity Peak





Rebustco et al 2005

- (1) Central Metallicity peaks are probably produced by the central galaxy (De Grandi et al. 2004)
- (1) Then, why are they much broader than the light distribution of the central galaxy? It is a transport process!

AGN outbursts in CC clusters!



M87 at 90 cm (Owen et al 2000)

Observed in RADIO!

AGN outbursts are also observed

in X-ray!



AGN feedback is invoked to solve the cooling flow problem!



Central gas cooling time is very short, but gas is not cooled below ~1-2 keV (the expected cooled gas is not detected)!

There are non-cool core clusters!



Metal Distribution

Cool core clusters

Non-cool core clusters



The origin of NCC clusters is unclear!

 People used to think that mergers destroy CC clusters and produce NCC clusters.

 However, numerical simulations suggest that CC systems are remarkably robust in mergers--CC systems are only disturbed by direct collisions with incoming cores

 Numerical simulations also suggest that mergers do not destroy central metallicity peaks



Poole et al 2008

AGN outbursts



M87 at 90 cm (Owen et al 2000)

Our feasibility study confirms that strong AGN outbursts can remove cool cores!



When AGN energy is injected into a typical cool core cluster



E~3 × 10^{61} erg

The cluster relaxes to NCC state.



Evolution of metallicity profile



Guo & Mathews 2010b

Central metallicity peak is difficult to be removed!



What about narrow metallicity peaks?



When can AGN remove central metallicity peaks?



Guo & Mathews 2010b

Conclusion and implications: Cosmic Evolution of Metallicity Profiles

- * Central metallicity peaks may be produced by cluster central galaxies (De Grandi et al 2004)
- * AGN feedback events broaden the central metallicity peak (Rebusco et al 2005)
- * Broad central metallicity peaks are very difficult to be removed (Poole et al 2008; Guo & Mathews 2010b)
- * Most low-redshift CC clusters have broad central metallicity peaks (De Grandi et al 2004)
- NCC clusters without central metallicity peaks may form from CC systems with narrow central metallicity peaks at slightly higher redshifts (Guo & Mathews 2010b)

Compare with observations



Guo & Mathews 2010b

