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DYNAMICS OF FAINT CLUSTERS OF GALAXIES

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Abstract. Recent studies with high-resolution cameras have extensively showed that clusters of galaxies are not as relaxed as we assumed. With its advent technology XMM-Newton allows us to obtain the temperature and metal abundance map in detail. In this study, we present our results related to six (A194, A1056, A1674, A1882, A2634, A2638) nearby ($z<0.14$) clusters. These clusters have very poor X-ray atmosphere (ICM) and therefore it is very efficient to study individual galaxies and their evolution within ICM. Based on the temperature maps and morphology of bright member galaxies, we try to understand the perturbed galaxy emissions and dynamics of the clusters itself.

1. INTRODUCTION

Before the new generation of X-ray missions (XMM-Newton, Chandra, Suzaku), it was believed that clusters with spherically symmetric surface brightness distribution were dynamically relaxed systems. We could hardly map the dynamical structures of even faint clusters. Today we can trace small scale fluctuations caused by a cluster-cluster merging event even in clusters with no clear asymmetric brightness structure.

In order to understand ICM dynamics of faint clusters of galaxies, we selected six of faint clusters of galaxies from the archival data. The temperature and metal distribution are studied, optical and radio properties are considered to understand morphology of the selected samples. We assume Hubble constant $\mathrm{H_0}$ =75 $\mathrm{kms^{-1}Mpc^{-1}}$ and cosmological deceleration parameter of $\mathrm{q_0}$ =0.5. The quoted uncertainties for the best fit parameters of spectral fittings are given for 90% confidence range.

2. ANALYSIS

We analysed archival X-ray data obtained from XMM-Newton archival observations. The three EPIC instruments, the two MOSs and the PN, were used. The cameras were operated in the Prime Full Window mode for MOS (Turner et al. 2001) and Prime Full Window Extended mode for PN (Strüder et al. 2001). The thin filter was used for all EPIC cameras. We processed the observation data files and created calibrated event files using the SAS version 7.0.0. The event lists were generated from the observation data files (ODF) by the tasks EMCHAIN and EPCHAIN.

In the standard analysis, the events were selected with PATTERN 0-12 for MOS and single and double pixel events PATTERN 0-4 for PN. In order to exclude the contribution from the background flare events, we extracted light curves for the full field of view. We thus choose 10-12 keV energy band for MOS and 12-14 keV for PN. The extracted light curves were clipped to clean the contamination by soft proton flares as described by Hudaverdi (2005). These Good Time Intervals (GTI) were applied to the event lists and filtered events files are produced. Figure A shows XMM-Newton 0.3-10.0 keV energy band merged image. The image is raw, non-background subtracted and adaptively smoothed to enhance cluster emission above the background emission.

XMM-Newton archival data is used in order to study evolutional histories of 6 clusters. The source detection is performed at both soft and hard X-ray bands. Figure A also shows brightness contours. We also study the radio properties of the clusters and overlaid the radio contours in red on DSS-optical image (Figure B). The temperature (Figure C) and metal distributions (Figure D) are mapped using wavelet mapping techniques (Bourdin et al. 2004). The X-ray brightness contours are overlaid in black color in all figures for visual aid.

3. SOURCE SAMPLE

3. 1. ABELL 194

ABELL 194 is a nearby (z=0.018) linear-cluster in NE-SW direction and very faint in X-rays. It is also bright in the radio band. The temperature map indicates large scale dynamics along N-S direction. The hot regions coincide with the radio-lobes which is a good example of ICM-radio relation. The central region is not abundant in terms of heavy metals. Probably, there is no significant metal ejection yet.

3. 2. ABELL 1056

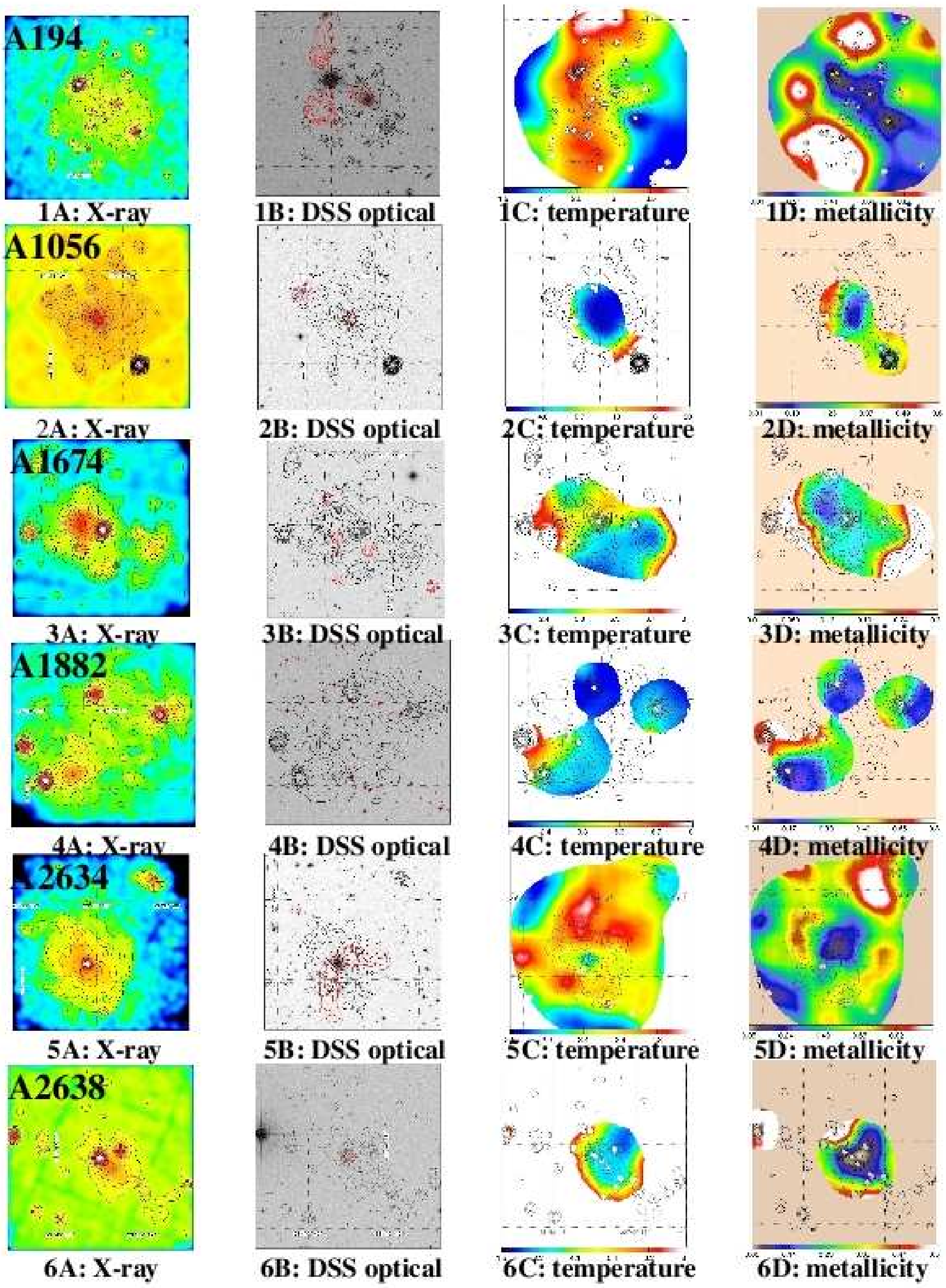
The cluster is located at z=0.08. The clustering is not around the brightest source. The cD galaxy is a strong radio emitter. Extend gas clustering is weak. We detected >20 point sources at the cluster outskirts (>1Mpc). There is no peculiar temperature structure. A closer look at the cool-core shows NE elongation. Metal distribution is in N-S direction. This may be the elongation of the previous dynamics of ABELL 1056.

3. 3. ABELL 1674

It is faint, nearby cluster at z=0.1066. There is a hot-gas (5.5 keV) passing along the cluster in an E-W direction, perpendicular to apparent X-ray elongation. The center has very low metal abundance (<0.07) also studied by Katayama et al (2005). The west part is cool and has a temperature of 2.5 keV. The hot-gas is indication of a recent merger.

3. 4. ABELL 1882

(z=0.1367) The cluster is composed of three parts. Southern part (center) and 2 blobs at the north. The diffuse gas is at a temperature of 2.5 keV. The other parts also show low temperature values (<2 keV). There are plenty of point sources within the cluster and at the outskirts, which gives us a good chance to make a comparative study of the environmental effects on galaxies.



A: *X-ray (0.3-10 keV.) images.* ***B:*** *DSS-optical images overlaid by X-ray and radio contours.* ***C:*** *Temperature maps.* ***D:*** *Metal abundance maps.*

3. 5. ABELL 2634

(z=0.0314) The cluster has a very bright cD galaxy, with a strong radio emission. The core gas is at 3 keV. There is peculiar temperature variation associated to radio-jets. The northern part is noticeably hotter (4.5 keV). The hot region is accompanied with very low metal abundance (<0.1 solar). The cluster is surrounded by high metallicity gas in the NE and SW regions which are evidences of previous mergers.

3. 6. ABELL 2638

(z=0.0825) The cluster is very faint in X-rays. The cD galaxy is also a radio source. The X-ray sources are aligned in NE-SW direction. The alignment can also be traced in the temperature map. The central 5 arcmin region has a uniform temperature at 2.8 keV and very low metallicity (<0.1). There is a cool (∼2 keV) region, possibly entailed to the second brightest source at NW.

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