AN XMM-NEWTON VIEW ON RELAXED AND NON-RELAXED CLUSTERS OF GALAXIES

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ABSTRACT

XMM-Newton observations have allowed to draw temperature maps for the X-ray emitting gas in clusters of galaxies, showing evidence for violent mechanisms rather than peacefully relaxed structures. We present temperature maps for four very different clusters and show how their interpretation gives insight on the merging history of these clusters.

Key words: X-rays; clusters of galaxies.

1. INTRODUCTION

In the standard ΛCDM cosmological picture the latest objects to collapse are $\sim\ 10^{14} - 10^{15} M_\odot$ dark halos, corresponding to rich clusters of galaxies. These objects present signs of recent dynamical activity, implying a recent past of merger events. XMM-Newton now allows to draw intra-cluster gas temperature maps and to obtain informations on the cluster formation and evolution histories.

2. RESULTS: FROM CLUSTERS STILL FORMING TO RELAXED CLUSTERS

The XMM-Newton temperature maps were computed for the four clusters described here following the method fully described by Durret et al. (2005). These maps are displayed in Fig. 1.

Abell 2667 (z=0.233) is a rich, massive cluster, with bright gravitational arcs and optical intra-cluster diffuse light (Covone et al. 2005) aligned along a north-east to south-west direction. The general shape of the X-ray emission is aligned along the same direction, and the X-ray temperature map shows hotter regions than average south west and north east of the centre, that is along the cluster main axis, along which one or two sources of diffuse light are also detected. This suggests that the gas could have been shock heated in a past merging during which the diffuse light may have been created by stars stripped from galaxies by ram pressure.

Abell 85 (z=0.0555) consists of a main structure, a south-blob and a filament made of groups falling towards the main cluster (Durret et al. 2003, 2005). The XMM temperature map shows a hotter region between the south blob and the centre of Abell 85 corresponding to the heating of the ICM by the shock of the infalling groups from the filament. Several hot spots seen in the west half of the cluster strikingly resemble the temperature map derived from numerical simulations by Bourdin et al. (2004), strongly suggesting that a sub-cluster merged with Abell 85 a few Gyrs ago coming from the west. This is consistent with recent VLA observations showing that HI is detected in galaxies located in the east half of the cluster but not in the west half, therefore suggesting that their HI content has been stripped by a merger coming from the west (Bravo-Alfaro et al. in preparation).

Abell 3376 (z=0.0456) is probably the result of an ongoing merger. Its X-ray emission has a “bullet” structure, pointing towards the north-east, remindful of the “bullet cluster” observed by Markevitch et al. (2002, also see these proceedings). The XMM temperature map, shows a succession of cold and hot arcs suggesting the passing of shock waves, as in the simulations by Takizawa (2005).

Abell 496 (z=0.033) appears to be a very relaxed cluster from its X-ray emission map. However, its X-ray temperature map shows small signs of substructure, with somewhat cooler gas seen near the centre to the South and a possible “bubble” of hotter gas just south of the center (also see Dupke et al., these proceedings).

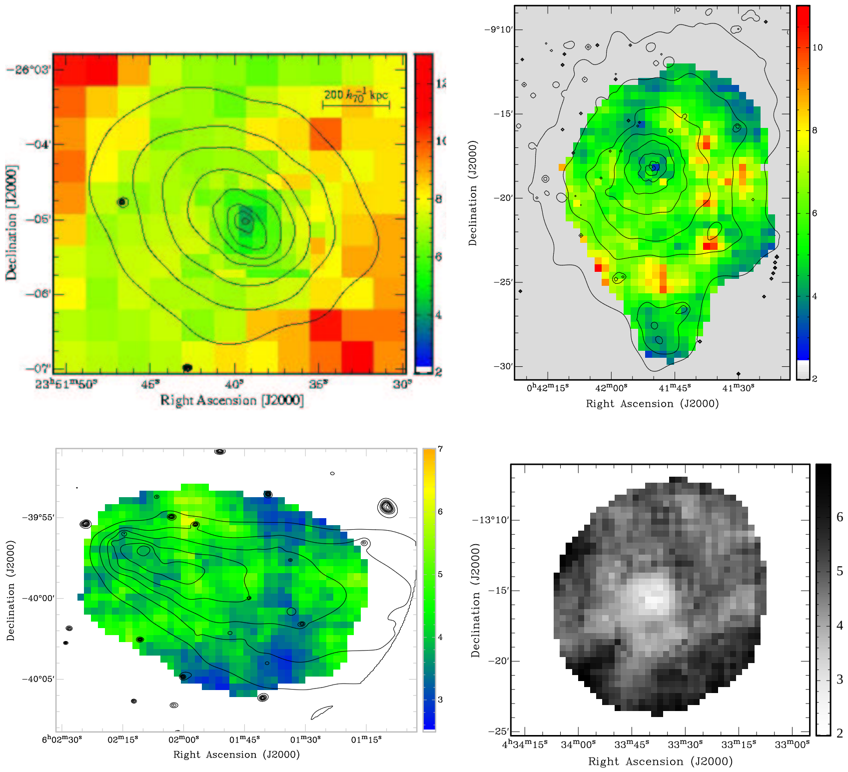

Figure 1. XMM-Newton temperature maps for the clusters of galaxies Abell 2667 (top left), Abell 85 (top right), Abell 3376 (bottom left) and Abell 496 (bottom right).

3. CONCLUSIONS

Thanks to the unprecedented sensitivity of XMM-Newton, detailed intra-cluster gas temperature maps can now be obtained, giving crucial informations on the formation and evolution histories of clusters. They allow in particular to trace the merging histories of clusters. Obviously, not two clusters are alike, an therefore an individual analysis of their properties is required before any statistical study can be made. Besides, even clusters with apparently smooth X-ray emission can show complicated temperature maps, implying that the number of really relaxed clusters is notably smaller than previously believed. One must therefore be careful when estimating, for example, total cluster masses, or when deriving cosmological parameters from a sample of clusters. The results described above also illustrate the fact that multi-wavelength observations are obviously necessary to analyze such complex objects. The complexity of nearby clusters is not unexpected of course, since it agrees with the generally accepted paradigm of hierarchical formation of structures.

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