The structural and scaling properties of nearby galaxy clusters: I - The universal mass profile

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Abstract. We present the integrated mass profiles for a sample of ten nearby \((z \leq 0.15)\), relaxed galaxy clusters, covering a temperature range of \([2 - 9]\) keV, observed with XMM-Newton. The mass profiles were derived from the observed gas density and temperature profiles under the hypothesis of spherical symmetry and hydrostatic equilibrium. All ten mass profiles are well described by an NFW-type profile over the radial range from 0.01 to 0.5\(R_{200}\), where \(R_{200}\) is the radius corresponding to a density contrast of 200 with respect to the critical density at the cluster redshift. A King model is inconsistent with these data. The derived concentration parameters and total masses are in the range \(c_{200} = 4 - 6\) and \(M_{200} = 1.2 \times 10^{14} - 1.2 \times 10^{15}\) \(M_{\odot}\), respectively. Our qualitative and quantitative study of the mass profile shape shows, for the first time, direct and clear observational evidence for the universality of the total mass distribution in clusters. The mass profiles scaled in units of \(R_{200}\) and \(M_{200}\) nearly coincide, with a dispersion of less than 15% at 0.1\(R_{200}\). The \(c_{200}-M_{200}\) relation is consistent with the predictions of numerical simulations for a \(\Lambda CDM\) cosmology, taking into account the measurement errors and expected intrinsic scatter. Our results provide further strong evidence in favour of the Cold Dark Matter cosmological scenario and show that the dark matter collapse is well understood at least down to the cluster scale.

Key words. Cosmology: observations, Cosmology: dark matter, X-rays: galaxies: clusters

1. Introduction

The Dark Matter (DM) distribution in clusters is a sensitive test of current scenarios of structure formation and of the nature of the DM itself. Of particular interest are comparisons with the predictions of \(N\)-body simulations of hierarchical clustering in the currently favoured \(\Lambda CDM\) (Cold Dark Matter) cosmology. Numerical simulations (e.g. Navarro et al. 1997), as well as early semi-analytical work (e.g. Bertschinger 1985), predict a remarkable similarity in the Cold Dark Matter density profile of virialized halos. Although the exact slope in the very centre is still a matter of debate, recent high resolution simulations predict that dark matter profiles are cusped (Navarro et al. 1997; Moore et al. 1999; Diemand et al. 2004; Navarro et al. 2004), and that the concentration of the Dark Matter varies only slightly with system mass (e.g. Dolag et al. 2004).

The strong similarity in the \(ROSAT\) surface brightness profiles (Vikhlinin et al. 1999; Neumann & Arnaud 2001; Arnaud et al. 2002), and of the temperature profiles of hot clusters observed with \(ASCA\) and BeppoSAX (Markevitch et al. 1998; Irwin & Bregman 2000; De Grandi & Molendi 2002) provided indirect evidence of a universal underlying dark matter distribution. The present generation of X-ray satellites, \(XMM-Newton\) and \(Chandra\), represent a giant step forward in terms of resolution and sensitivity. We can now measure precisely, through the hydrostatic equilibrium equation, the total mass distribution in clusters. Evidence is slowly accumulating that \(CDM\) numerical simulations predict the correct shape of the Dark Matter distribution, not only in massive clusters (e.g. David et al. 2001; Allen et al. 2001; Arabadjis et al. 2002; Buote & Lewis 2004; Buote 2004; Allen et al. 2003), but also in low mass clusters (Pratt & Arnaud 2003). This may well be true up to the virial radius, as shown up to \(\delta = 500\) by the observation of A1413 (Pratt & Arnaud 2003). The observed profiles are cusped in the centre, and, for a few massive clusters, the inner slope has even been measured precisely enough to distinguish between various \(CDM\) predictions (Lewis et al. 2003; Buote & Lewis 2004; Pointecouteau et al. 2004). However, most mass studies have been conducted on individual ‘test case’ clusters. Recently, Pratt & Arnaud (2005) performed the first quantitative check of the universality of the mass profile using a sample of five clusters observed with \(XMM-Newton\) (four low mass systems compared to one massive system). It is necessary to extend this type of study to larger samples, with a better temperature (i.e., mass) coverage.

In this paper, we use \(XMM-Newton\) to examine the total mass profile of ten relaxed, nearby clusters in the temperature range from 2 to 9 keV. In a companion paper (Arnaud,
the four additional clusters, although some details obtained with the same general method that we use to process sections. Further details and comments on each individual cluster to cluster. The procedure is described in the next four sections. We quantify the shape of the mass profiles in Section 3. Our results are discussed and we conclude in Sec. 4.

We have used the currently favoured ΛCDM cosmology, $H_0 = 70$ km/s/Mpc, $\Omega_m = 0.3$ and $\Omega_\Lambda = 0.7$, throughout this paper.

2. XMM-Newton observations and data processing

2.1. The sample

The sample has been built to cover a wide range in temperature (i.e. in mass) from 2 to 9 keV, and constitutes 10 clusters. We limited the redshift range to $z \leq 0.15$, where evolution effects are expected to be negligible. With the exception of A478 and PKS0745, for which there was a mosaic observation, we only considered clusters fitting in the XMM-Newton field of view, enabling the local background to be estimated, thus limiting systematic uncertainties on the temperature, and consequently, the mass profiles. Since cluster size increases with temperature, this last criterion sets a lower limit on the redshift for each temperature. Cool and hot clusters lie in a redshift range close to this limit ([0.04, 0.06] and [0.1 – 0.15] respectively). This thus optimizes both the cluster coverage and the statistical quality of the data. A final selection criterion was the quality of the mass data. All clusters in the sample have a regular X-ray morphology, indicative of a relaxed state and allowing reliable determination of the total mass profile through the hydrostatic equilibrium equation.

Our sample includes the sample of Pratt & Arnaud (2005): the cool clusters A1983, A1991, MKW9, A2717, and the hot cluster A1413. We improved the temperature coverage by adding A478 (recently studied by Pointecouteau et al. 2004), and four clusters at intermediate and high temperature from the XMM-Newton archive which meet our criteria. The journal of observations is presented in Table 1.

To minimise systematic errors in the statistical study of cluster properties, it is important to use scientific data derived, as far as possible, with the same procedure. Unless otherwise stated, we use the previously published data of the cool clusters (Pratt & Arnaud 2002, 2005), A478 (Pointecouteau et al. 2004) and A1413 (Pratt & Arnaud 2002). These results were obtained with the same general method that we use to process the four additional clusters, although some details differ from cluster to cluster. The procedure is described in the next four sections. Further details and comments on each individual target are given in Appendix A.

2.2. Event list processing

We used the XMM-Newton sas software package, versions 5.3 or 5.4, to filter the data. Below we detail the main

\[ H_0 = 70 \text{ km/s/Mpc}, \quad \Omega_m = 0.3 \quad \text{and} \quad \Omega_\Lambda = 0.7 \]

Notes:
1. EPN observation mode: FF = Full Frame, EFF = Extended Full Frame; b Exposure time (EMOS1/EMOS2/EPN) in ksec after flare cleaning; c The exposure times are given for the central pointing.

data processing steps.

1. Considering only events with $\text{FLAG} = 0$ and $\text{PATTERN} \leq 12$ (EMOS) and $\text{PATTERN} = 0$ (EPN), we clean the data for soft proton flares using a threshold cut method (see appendix A in Pratt & Arnaud 2002). A first screening was performed using light curves in the high energy band ([10-12] keV for EMOS, [12-14] keV for EPN) using 100s bins. After filtering using the good time intervals from this screening, a second screening was performed as a safety check-up. A second light curve built in 10s bins in a wider energy band ([0.3-10] keV for EMOS, [0.3-12] keV for EPN) was screened, and the event lists were filtered accordingly.
2. To correct for the vignetting effect, we used the photon weighting method (Arnaud et al. 2001). The weight coefficients were computed by applying the sas task evgweight to each event file (including background files).
3. The point source lists from the SOC pipeline were visually checked on images generated for each detector. Selected point sources from all available detectors were gathered into a single point source list and the events in the corresponding regions were removed from the event lists. The area lost due to point source exclusion (as well as CCD gaps and bad pixels) was computed using a mask image.

We used XMM-Newton dedicated blank field datasets from either Lumb et al. (2002), or Read & Ponman (2003) to obtain a background event list associated with each data set. For each cluster, the blank field event list was recast in order to match the astrometry of the observation and was then processed in the same way as the observation event list. (This included extraction of the events in the same regions as the point sources in the observation data set.) To account for variations in the particle background level, we assumed that only particle signal is collected at high energy, and used the ratio between the two from point to point in the final stacked exposure map. We took this variation into account in our analysis.

Table 1. Journal of observations

| Cluster   | $z$  | Rev. | Mode $^*$ | $t_{exp}$ (ksec) |
|-----------|------|------|----------|-----------------|
| A1983     | 0.0442 | 400 | EFF      | 18/18/12        |
| A2717     | 0.0498 | 558 | FF       | 52/52/44        |
| MKW9      | 0.0382 | 311 | EFF      | 30/30/21        |
| A1991     | 0.0586 | 584 | FF       | 29/29/19        |
| A2597     | 0.0852 | 179 | FF       | 16/15/10        |
| A1068     | 0.1375 | 633 | FF       | 19/20/15        |
| A1413     | 0.1430 | 182 | EFF      | 24/25/10        |
| A478      | 0.0881 | 401,411 | EFF      | 48/41/37$^c$ |
| PKS 0745  | 0.1028 | 164 | –        | 10/10/5         |
| A2204     | 0.1523 | 322 | FF       | 20/20/13        |

Notes: $^a$ EPN observation mode: FF = Full Frame, EFF = Extended Full Frame; $^b$ Exposure time (EMOS1/EMOS2/EPN) in ksec after flare cleaning; $^c$ The exposure times are given for the central pointing.

We rescaled the published values of A1983 and A1413 to the ΛCDM cosmology used in this paper.
of the blank field data, and subsequent subtraction of the Cosmic X-ray background residual estimated from a region free of cluster emission.

2.3. The density profile

For each cluster, an azimuthally-averaged, background subtracted surface brightness (SB) profile was computed in the soft energy band ([0.3-2.] keV in the present work) for each available detector\(^3\). The profiles of all detectors were then summed together into a total SB profile and rebinned with logarithmic radial binning and a minimum S/N ratio of 3. The profile was corrected for radial variations of the emissivity (e.g. due to abundance or temperature gradients) in the energy band considered (see Pratt & Arnaud 2003 for details). This corrected profile is thus proportional to the emission measure along the line of sight.

The final SB profiles were fitted using parametric analytic models of the gas density profile, converted to an emission measure profile and convolved with the PSF spatial response (Ghizzardi 2001, 2002). We considered various parametric forms and empirically chose the model best fitting the data using the \(\chi^2\) statistic as a measure of the goodness of fit. The models included a double-\(\beta\)-model (the BB model defined in Pratt & Arnaud 2003), a modified double-\(\beta\)-model, which allows a more concentrated gas density distribution towards the centre (the KBB model used by Pratt & Arnaud 2002 for A1413), and the sum of three \(\beta\)-models in which a common value of \(\beta\) is assumed to ensure smooth behaviour at large radii (the BBB model used by Pointecouteau et al. 2004 to model the SB profile of A478). For the clusters newly analysed here, the best fitting model was either a KBB model (A2597, A1068 and PKS 0745-191) or a BBB model (A2204). Over the whole sample the reduced \(\chi^2\) values vary from 1.1 (for A478), to 1.5 (for A1068), and thus even the best parametric model leads in some cases to a formally unacceptable fit. This is linked to the very small statistical errors on each measurement. The actual discrepancies between the model and the data remain small: adding a few percent (2 to 5%) of systematic error while fitting the data always leads to acceptable \(\chi^2\) values.

2.4. The temperature profile

Concentric annular regions were defined from the total background subtracted SB profile of the cluster the clusters newly analysed here, we used the following empirical method to define the annuli from which the spectra were extracted. We started with a minimum bin size of 15” (e.g about the HEW of the XMM-Newton PSF) and then increase the bin size by a logarithmic factor of 1.05. This is sufficient in the central parts to keep a good S/N, but not in the outer regions. We thus further impose, in the outer regions, that the numbers of cluster counts per bin is approximately constant, within 5%.

For each annular region, a background subtracted spectrum was extracted for each available detector. The spectra from each detector were then simultaneously fitted using xspec (Arnaud 1996) with an absorbed, redshifted single temperature plasma model (WABS*MKAL). Except in the case of A478 (see Pointecouteau et al. 2004 for details), after checking that the \(N_H\) value agreed with the galactic 21 cm value (from Hartmann & Burton (1999)), this parameter was frozen. Thus we derived an annular temperature profile for each cluster in the sample, as shown in the left panel of Fig. 1. All profiles (except that of A1413) have the same generic shape: a negative gradient towards the centre and a roughly flat external plateau. A1413 is the only cluster for which we observe a significantly decreasing temperature at high radii (of about 20%).

To derive the true radial temperature profile (needed to compute the mass profile) we should take into account projection and PSF effects. For the typical temperature profile shape we have obtained, these effects depend most strongly on the magnitude of the gradient in the centre. In addition, a strong temperature gradient in the central regions is usually associated with a strongly peaked surface brightness profile, further increasing the PSF blurring\(^4\). Reconstructing the radial temperature profile in these cases is not a trivial task. General non-parametric methods, such as simultaneous fitting of annular spectra, amplify the noise considerably. This yields radial temperature profiles with unphysically large fluctuations, particularly when both PSF and projection effects are important (see discussion in Pointecouteau et al. 2004).

The clusters newly analysed in the present work have quite strong ‘cooling flows’. We thus applied the method developed for A478 by Pointecouteau et al. (2004), in which the radial temperature profile is derived from the annular temperature profile in the following manner. The noise amplification problem is avoided by using smooth parametric representation of the annular temperature profile. We used the function given by Allen et al. (2001): \(T(r) = T_0 + T_1 \left( \frac{r/r_0}{1 + r/r_0} \right)\) to fit the ann-

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\(^3\) We also computed background subtracted SB profiles in the high energy band (we recall: [10-12] keV for EMOS and [12-14] keV for EPN) to check that there were no significant residuals, i.e., that the normalisation of the blank field background was correct, and that it was indeed constant with radius.

\(^4\) The effects of the PSF correction are most noticeable for A2204 and A478.
The best fitting model profile is then corrected for both the projection and PSF effects, assuming that the annular temperatures are emission weighted temperatures (see Pointecouteau et al. 2004, for details). To estimate the errors we repeated the procedure 1000 times, using a Monte Carlo method that randomizes the annular profile based on the observed errors. Because using a specific functional form effectively limits the allowed profiles, the standard deviation of the corrected temperature at a given point is occasionally smaller than the error on the annular temperature. When this was the case, we kept the observed error.

For the poor systems, which have a more modest central temperature gradient, the radial temperature profile was estimated as described in Pratt & Arnaud (2003, 2005). For A1413 PSF and projection effects proved to be negligible (Pratt & Arnaud 2002). The deprojected, PSF corrected profiles of all the clusters are shown in the right panel of Fig. 1. A detailed discussion of the shape of these temperature profiles is beyond the scope of this paper.

### 2.5. The total mass profile

The mass profile for each cluster was derived from the best fitting density profile and the deprojected, PSF corrected temperature profile under the assumptions of hydrostatic equilibrium and spherical symmetry:

\[
M(r) = -\frac{kT r}{G\mu m_p} \left[ \frac{d\ln n_e}{d\ln r} + \frac{d\ln T}{d\ln r} \right].
\]

The mass, and associated errors, were then computed at each radius of the temperature profile\(^5\) using a Monte Carlo method that randomizes the temperature profile based on the observed errors (Pratt & Arnaud 2003). A cubic spline interpolation is used to compute the temperature derivative at each radius. Only mass profiles which monotonically increase with radius were kept (1000 in total). The errors due to the errors on the density gradients, which are negligible with respect to those from the temperature, were then added. The mass profile of A1413 was originally derived using a slightly different Monte Carlo method (Pratt & Arnaud 2002). For homogeneity of the present study, we re-derived the mass profile of this cluster with the present method, allowing us to extend the profile to lower radii\(^6\). The new mass profile is perfectly consistent with the published one.

Each cluster has been checked for the presence of structure such as cold fronts, hot bubbles, ghost cavities, or other effects which could affect the mass determination. Details of each cluster are given in Appendix A.

### 3. The shape of the mass profile

#### 3.1. Mass profile modelling

For each cluster, three mass models were fitted to the data: (i) a King isothermal sphere profile; (ii) a standard NFW profile (Navarro et al. 1997); and (iii) an MQGSL profile (Moore et al. 1999). Our data indicate that an isothermal sphere model (i.e., a profile with a core) is not a good representation of the mass distribution in these clusters. Dropping too rapidly in the centre and flattening in the outer regions, the reduced \(\chi^2\) obtained from King model fits ranged from 1.65 for A478 to 15.6

\(^5\) We use in fact the weighted effective radius of each annulus (Lewis et al. 2003).

\(^6\) Pratt & Arnaud (2002) used the original Monte Carlo method of Neumann & Böhringer (1999). This method uses a ‘diffusive’ process to calculate random temperatures at equally spaced radii. It has two parameters, the radial step and a window parameter, which are optimised to ensure smooth random temperature profiles. In this original version of the code, the radial step fixed the minimum radius of the mass profile. In the present method it is simply the radius of the first temperature annulus.
MQGSL model, and A2597, the NFW profile proved to be a better fit than the account. we are not able to quantify and are therefore unable to take into PSF and projection e points may be underestimated due to the procedure used for (A478). In contrast, the reduced for A1068. It is rejected with a minimum 91% confidence level (A478). In contrast, the reduced χ² of 0.5 (A1413) to 5.21 (A2717). We note that the chi-squared value is very sensitive to the central points. In some cases, the mass errors on these points may be underestimated due to the procedure used for PSF and projection effects correction, or to systematic errors we are not able to quantify and are therefore unable to take into account.

In all cases barring A1413 (Pratt & Arnaud 2002) and A2597, the NFW profile proved to be a better fit than the MQGSL model, and de facto to be the best representation of our current data. In the cases of A1413 and A2597, the improvement in χ² when an MQGSL profile is used is very small. Thus, to keep our approach coherent, we decided to use the NFW fit as a parametric representation of the mass profile of each cluster.

The NFW model, where the density is ρ(r) ∝ (r/r_s)(1 + r/r_s)^{-1}, has two free parameters: the scaling radius r_s, and a normalisation parameter. The model can be equivalently expressed in terms of the concentration parameter c_{200} = r_{200}/r_s and the total mass M_{200}. M_{200} is the mass corresponding to a density contrast of δ = 200, i.e. the mass contained in a sphere of radius R_{200}, which encompasses a mean density of 200 times the critical density at the cluster redshift: ρ_c(z) = 3E(z)^2H_0^2/8πG, where E^2(z) = Ω_m(1 + z)^3 + Ω_Λ. In numerical simulations, this sphere is found to correspond roughly to the virialised part of clusters. The results of the best NFW fits are detailed in Table 2 and the best fitting profiles are shown in Fig 4.

3.2. Scaled mass profiles

The left panel of Fig 4 shows the mass profiles (and best-fitting NFW models) plotted in physical units (kpc). Not surprisingly, there is a continuous increase in mass with cluster tempera-
The numerical simulations of Dolag et al. (2004). The dotted lines are at 0.15 \( (\text{the maximum redshift for our sample}) \). The long-dashed line stands for our best fit of the \( c_{200} - M_{200} \) (see text).

The solid line represents the variation of \( c_{200} \) for clusters at \( z = 0 \) from the numerical simulations of Dolag et al. (2004). The dotted lines are the standard deviation associated with this relation. The dashed line represents the same relation at a redshift of 0.15 \( (\text{the maximum redshift for our sample}) \). The long-dashed line stands for our best fit of the \( c_{200} - M_{200} \) (see text).

3.3. Variation of the concentration parameter with mass

Structure formation models do not in fact predict a strictly universal matter distribution in clusters. A weak variation in the concentration is expected from low to high mass clusters, reflecting differences in the formation epochs of low and high mass haloes (Navarro et al. 1997; Bullock et al. 2001; Dolag et al. 2004). Building on the work of Pratt & Arnaud (2005), their Fig. 12, we can investigate the relation between the concentration parameter and the cluster mass using our extended sample. Figure 3 presents the \( c_{200} - M_{200} \) relation found by Dolag et al. (2004) \((1+z)\bar{c} = c_0(M/M_0)^{\alpha} \) with \( \alpha \sim -0.1 \) in a \( \Lambda \text{CDM} \) cosmology with \( \sigma_8 = 0.9 \). All ten points agree with the predicted relation, taking into account its intrinsic dispersion and the measurement errors.

We then performed a linear regression fit in the log \( c_{200} - \log M_{200} \) plane, taking into account the uncertainties on each quantity. The resulting slope of \( \alpha = -0.04 \pm 0.03 \) \((\chi^2 \text{ (dof) } = 42(8)) \) is poorly constrained, due in part to the limited size of the sample and the large relative uncertainties in the concentration parameter. The result is however compatible with the intrinsic dispersion of theoretical predictions. The best fitting \( c(M) \) relation is shown as the long dashed line in Fig. 3.

4. Discussion and conclusion

We have measured the total mass profile of ten clusters from 0.01\( R_{200} \) up to 0.5\( R_{200} \) using XMM-Newton observations. Our sample has an excellent temperature coverage and covers an order of magnitude in mass from \( M_{200} = 1.2 \times 10^{14} M_\odot \) to 1.2 \( \times 10^{15} M_\odot \). Our study confirms previous XMM-Newton and Chandra studies conducted on individual targets (see Sec. I), and extends the initial statistical study of cluster mass profile structure by Pratt & Arnaud (2005).

We have found that the NFW profile is a good representation of the ten observed mass profiles, and that in all cases the isothermal sphere model (i.e a profile with a core) is rejected at high confidence. In other words, we confirm the cusped nature of the Dark Matter profile, as predicted by CDM simulations of hierarchical structure formation, over the temperature/mass range of the present sample. The mass profile shape is close to universal, again as predicted, with a dispersion of less than 15\% at 0.1\( R_{200} \) in the scaled mass profiles. The shape is quantitatively consistent with theoretical predictions. The variation of the observed concentration parameters with mass is in line with the predictions, taking into account the measurement errors and the expected intrinsic scatter. However, our sample is still too small to draw any firm conclusions on the exact form of the \( c(M) \) relation. Taken together, our results provide further strong evidence in favour of the Cold Dark Matter cosmological scenario, and show that the physics of the Dark Matter collapse is well understood.

The exact inner slope of the CDM distribution in haloes remains an important theoretical issue (Diemand et al. 2004; Navarro et al. 2004). Few of our mass profiles have the required radial coverage and statistical quality in the central parts to allow us to firmly distinguish between an NFW-type profile and other types of cusped DM profile (e.g., the mass profile of A478). We caution also that the very central parts of clusters are regions of complex phenomena (hot bubbles, ghost cavities, cold fronts, interaction with the central galaxy, etc) which are still not well understood. Their effect on the ICM may challenge the hypothesis of hydrostatic equilibrium, and therefore the reliability of the X-ray mass estimate.

Observations are also needed of the outskirts of clusters. To date, those regions are basically unknown to observers, and can only be investigated with numerical simulations. Study of
A1991 – Sharma et al. (2004), using Chandra, have reported

A1983 – Pratt & Arnaud (2003) published an extensive study

A478 – From the Chandra observations, Sun et al. (2003) re-

A2204 – This is a very well relaxed cluster at a redshift of

Appendix A: Cluster specifics

For each cluster in our sample, we searched the literature for special features such as ICM bubbles, ghost cavities, cold fronts or other phenomena which could disturb the relaxed structure of the intra-cluster medium and therefore invalidate hypothesis of spherical symmetry and hydrostatic equilibrium. We particularly investigated existing Chandra observations of central substructure in clusters, capitalising on its high spatial resolution. We used this information to check our mass profiles and if needed to exclude one (or more) point(s) containing such substructure. Details and notes are now given for individual clusters.

A478 – From the Chandra observations, Sun et al. (2003) reported the presence of X-ray cavities within the 15 central kpc. The recent XMM-Newton observation of A478 Pointecouteau et al. (2004) excluded this inner area for the mass profile computation. We used the published mass profile of Pointecouteau et al. (2004).

A1068 – We chose this cluster for its intermediate temperature of about 4-5 keV. The data for A1068 were retrieved from the XMM-Newton archive. According to the Chandra observation detailed in Wise et al. (2004), no special inner structure has been seen.

A1413 – This cluster has been studied in detail by Pratt & Arnaud (2002). Among the sample it is the only hot cluster without a cool core, and the only cluster with a firmly observed decrease in temperature at large radii. It is also the cluster observed up to the largest radius (0.7R200). The existing (public) Chandra observation of this cluster has a too low an exposure time to show clearly whether there is structure in the cluster centre.

A1983 – Pratt & Arnaud (2003) published an extensive study of the XMM-Newton observations for this cluster. We used all the mass points published by those authors. No Chandra X-ray observation is yet reported for this cluster.

A1991 – Sharma et al. (2004), using Chandra, have reported low energy knots (kT ~ 0.8 keV) located at ~ 10 kpc from the cluster centre. The first bin of the temperature (and thus mass) profile, used by Pratt & Arnaud (2005) in their XMM-Newton study of A1991, extends up to 38 arcsec. The knot structure seen by Chandra is included in this bin and is therefore diluted within the cluster emission. Keeping or removing the first point in our mass analysis leads to mass modelling results which are compatible at a 1σ level. The NFW fit being slightly better when using all the points, we choose to use the whole mass profile published by Pratt & Arnaud (2005).

A2204 – This a very well relaxed cluster at a redshift of z = 0.1523 showing a very peaked emission profile toward the centre. The cluster hosts a very strong radio source at its centre, and recently Sanders et al. (2004) have pointed out complex structure in the very central part of the cluster using the Chandra satellite. In addition, as discovered in many other clusters, two cold fronts were observed at radii of about 30 and 80 kpc. While we computed the mass profile down to small radii for this cluster, we excluded in the mass analysis the two inner annuli, the outer radius of which extend up to 109 kpc, in order to avoid invalidating the assumption of hydrostatic equilibrium.

A2717 – Another poor cluster from Pratt & Arnaud (2005). No high resolution X-ray imaging has been performed to date on this cluster. However, a work based on ROSAT/PSPC and APM optical data aiming to find substructure in a sample of clusters (Kolokotronis et al. 2001), reported substructure in the optical for A2717. It is undetectable in this X-ray observation. No significant change occurring when excluding the central point from the fit, we used the entire computed mass profile.

A2597 – This cluster was taken from the XMM-Newton archive, and was chosen because of its intermediate temperature of about 3-4 keV. A2597 has been studied with the Chandra satellite, exhibiting ghost cavities in its centre at a radius of about 30 kpc (McNamara et al. 2001). Moreover, the Chandra SB profile and temperature profile seems to be quite disturbed up to a few tens of kpc. We therefore choose to ignore the two first data points of our mass profile and to only keep points with inner radii larger than 50″.

MKW9 – This cluster is the least regular of the three cool systems recently studied by Pratt & Arnaud (2005). However, lacking any external information on its central structure we use their published mass profile.

PKS 0745-191 – A previous analysis of XMM-Newton data was published by Chen et al. (2003). However, we decided to reprocess the whole dataset to keep the data processing in our sample coherent. The data for this cluster are strongly disturbed by important flaring periods. After flare cleaning, we kept only the MOS data, the EPN data being still very noisy. Our temperature profile is in total agreement with that of Chen et al. (2003), and also with the measurement by BeppoSAX at large radii (De Grandi & Molendi 1999). Note that the overall normalisation of our temperature profile is somehow lower to that obtained by Hicks et al. (2002) with the Chandra satellite. Indeed, these authors obtained a plateau temperature of about 10.5 keV above 200 kpc from the centre against our value of ~ 8 keV. Regarding the SB profile from the Chandra observation, which exhibits a sharp central cusp (mainly due to the cD galaxy), we improved the fit of the mass profile by excluding our central bin which extends up to 34″.
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