Exploring the Structure of Galaxy Clusters at $z \sim 0.3$

Precise determination of global properties of galaxy clusters and their scaling relations with cluster mass is a task of prime importance for the use of clusters as cosmological probes. In a detailed XMM-Newton study of thirteen X-ray luminous REFLEX Survey clusters at $z \sim 0.3$ we found that the clusters show in many properties a closely self-similar behavior. This helps to establish tighter scaling relations and to get good estimates of physical cluster properties from these global parameters which are easy to observe.

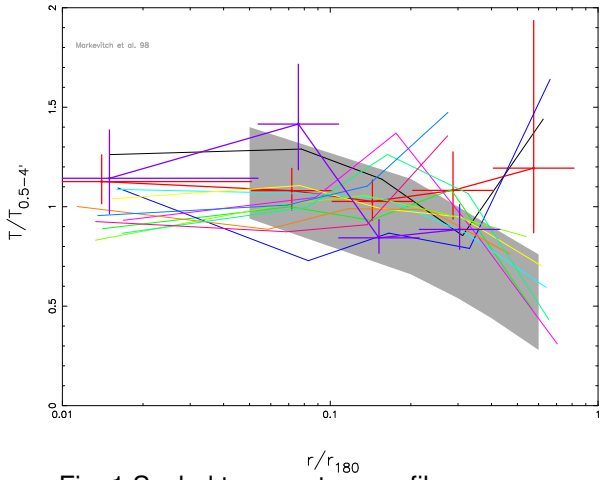

Fig. 1 Scaled temperature profiles.

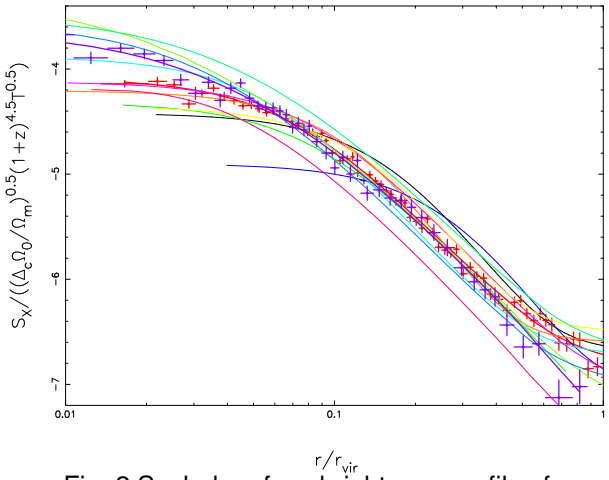

Fig. 2 Scaled surface brightness profiles for pn.

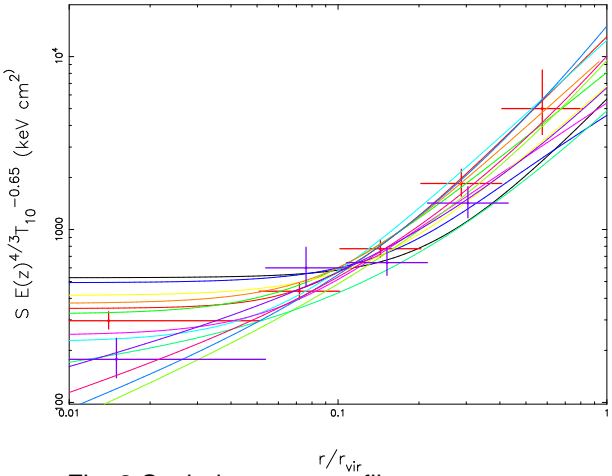

Fig. 3 Scaled entropy profiles.

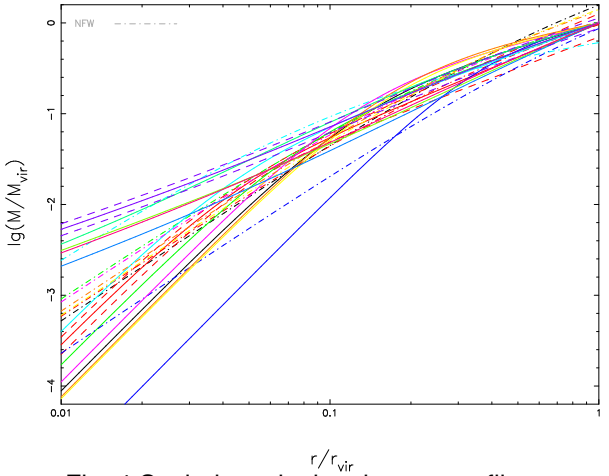

Fig. 4 Scaled gravitational mass profiles.

For our study we scale the properties to the cluster global parameters, e.g. radii scaled to the virial radii derived from the mass modeling using the ICM temperature and density profiles. We use r_{180} for the temperature profile scaling as shown in Markevitch et al (1998). We find: (1) very similar scaled temperature profiles with a broad maximum at $0.1r_{\rm vir}$, (2) self-similar surface brightness scaled according to the standard self-similar model (e.g. Arnaud et al. 2002) in which five cooling flow clusters (eight non-cooling flow clusters) are well fitted by an extended NFW (beta) model, (3) self-similar behavior of the entropy using the empirical temperature scaling of Ponman et al. (2003), and (4) gravitational mass profiles scaled by the virial mass in which the NFW model provides a satisfactory fit for the non-cooling flow clusters in the $r > 0.1r_{\rm vir}$ region and the cooling flow clusters show higher mass distributions in the cores. We adopt a flat Universe of $\Omega_{\rm m} = 0.3$, $\Omega_\Lambda = 0.7$, and $H_0 = 70$ km s^{-1} Mpc^{-1}. Error bars (confidence intervals as dashed curves) correspond to the 68% confidence level shown only for two typical examples: an example of a non-cooling flow (cooling flow) cluster is shown in red (blue).

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