



The ACCEPT2 database of galaxy clusters: early results on global properties and morphology

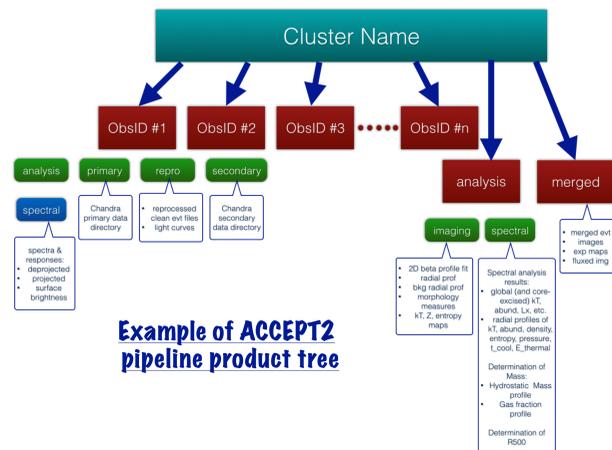


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The ACCEPT2 Project

- Chandra archival project to improve and extend the original ACCEPT database.
- As for its predecessor, the ACCEPT2 database, as well as the pipeline products will be **completely public**.
- Collection of observables from a total of **~600 galaxy clusters** (~400 also allowing a **spatially resolved** analysis) → the **largest available database of uniformly derived galaxy cluster X-ray properties**.
- Improved reduction and analysis pipeline (developed in Python) will yield:
 - uniform measures of global, core-excised and core T_X , L_X , and **metal abundances** for each cluster;
 - morphological and non-morphological **measures of cluster relaxation**;
 - radial surface brightness and spectra to derive **deprojected temperature, abundance, density, pressure, cooling time and entropy** profiles;
 - measures of the **gas mass and hydrostatic mass** profiles and estimates of the **total mass and gas fraction** inside R_{2500} ;
 - temperature, metallicity and projected entropy maps** (for observations with sufficient counts).



Abstract

The public ACCEPT database of cluster properties (Cavagnolo et al. 2008, 2009) included radial profiles of temperature, density, entropy, and cooling time. With the new ACCEPT2 project we are currently doubling the number of clusters in ACCEPT and expanding the current suite of properties to include uniformly measured profiles of mass along with signatures of dynamical relaxation (centroid shift, power ratios, surface brightness concentration, temperature ratios) and global quantities such as core-excised temperatures, X-ray luminosities, and metallicities. This project has the potential of yielding key results on the physics of galaxy clusters and cosmology and represent a benchmark for years to come, here we are highlighting the first early results obtained on the evolution of metal abundance content, the evolution of X-ray scaling relations, and the relation between cool cores and dynamical relaxation.

Evolution of X-ray Scaling Relations

- M-L_X, L_X-T, L_X-Y_X, etc. are expected to evolve with redshift in every cosmological model.
- Current data in the literature are not homogeneously derived and attempts at making literature data uniform yielded contrasting results (see e.g. Reichert et al. 2011, Giodini et al. 2013 and references therein).
- ACCEPT2, the largest sample of homogeneously derived cluster properties available to date, is ideal to study the evolution of scaling relations.

L_X-T relation

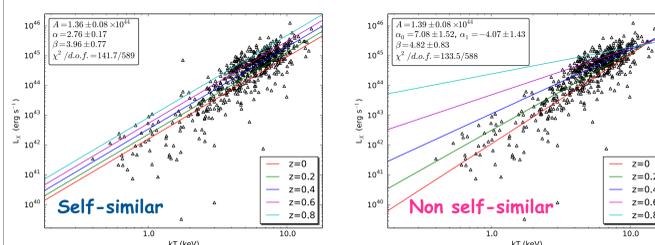
- In the self-similar scenario, no role is played by the scale in temperature or mass. As a result only the normalization depends on redshift, and the L_X-T relation can be fitted as:

$$L_X = A (T/5 \text{ keV})^\alpha E(z)^\beta$$

- Deviations from the self-similar scenario can be tested by introducing a dependence of the slope on redshift:

$$L_X = A (T/5 \text{ keV})^{\alpha_0 + \alpha_1 E(z)} E(z)^\beta$$

- Both functions are a good fit to the data, however a simple F-test on the χ^2 values obtained shows that the hypothesis that the self-similar model is a better fit can be rejected at a >99.9% confidence level.



M-L_X relation

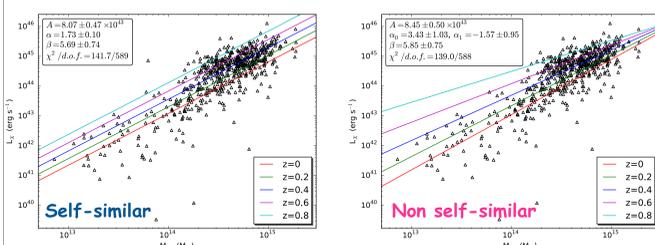
- Similarly for the M-L_X relation we fitted the self-similar model:

$$L_X = A (M/3 \cdot 10^{14} M_\odot)^\alpha E(z)^\beta$$

- And then introduced a dependence of the slope on redshift:

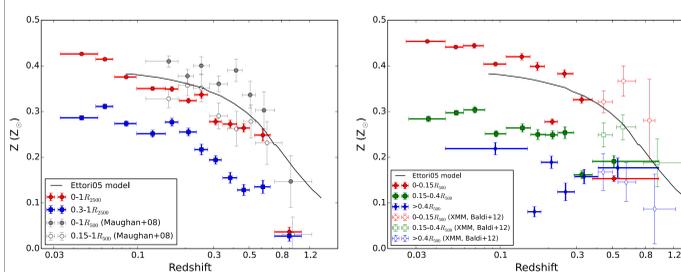
$$L_X = A (M/3 \cdot 10^{14} M_\odot)^{\alpha_0 + \alpha_1 E(z)} E(z)^\beta$$

- Also for the M-L_X relation, the hypothesis that the self-similar model is a better fit can be rejected at a >99.9% confidence level.



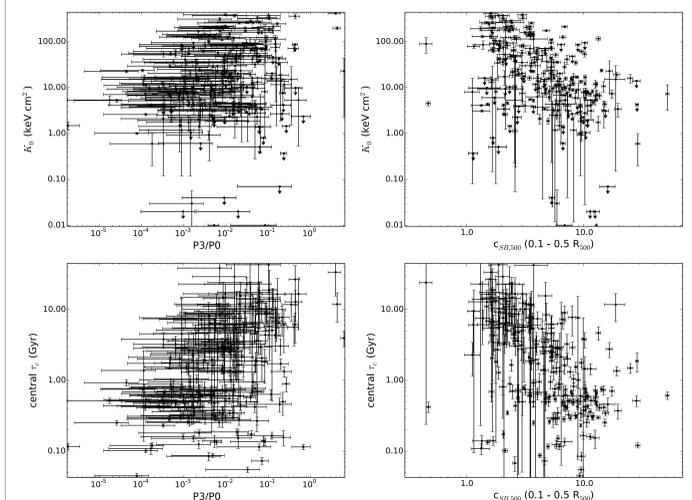
Evolution of Metal Abundance

- Several studies addressed the radial distribution of metals in the ICM at low redshift (Baldi et al. 2007; Leccardi & Molendi 2008; Snowden et al. 2008).
- Few others constrained the evolution of the metal abundance at $z \approx 0.3$ (e.g. Balestra et al. 2007; Maughan et al. 2008; Anderson et al. 2009), with a spatially resolved approach attempted in Baldi et al. (2012, 39 XMM clusters at $0.4 < z < 1.4$).
- ACCEPT2 allows to study the spatially resolved evolution of metals in a wide redshift range with unprecedented statistics.
- Preliminary results in agreement with evolutionary trends observed in Maughan et al. (2008), in Baldi et al. (2012) and with the predictions of Ettori (2005) model for abundance evolution derived from supernova yields.



Cool-Cores and Cluster Morphology

- The exact reason for the cool-core/non-cool-core dichotomy is still unknown, although at least partly related to relaxation, with relaxed clusters more likely to harbor cool cores (e.g. Pratt et al. 2010).
- With ACCEPT2 we are relating measures of relaxation to the incidence of cool cores, as measured with both the K_0 parameter (derived by fitting the entropy profiles with $K(r) = K_0 + K_{100} (r/100 \text{ kpc})^\alpha$) and central cooling time τ_c , on a firm statistical foundation.
- In a preliminary analysis (based on ~300 clusters), we found a clear correlation of K_0 and central τ_c with several of our morphological measures of relaxation such as the power ratio P3/P0 (e.g. Buote & Tsai 1995) and the surface brightness concentration c_{SB} (e.g. Santos et al. 2008):
 - lower K_0 /central τ_c corresponds to higher values of c_{SB} ;
 - lower K_0 /central τ_c corresponds to lower values of P3/P0.



Future Plans

- Our primary scientific goal is to establish how cluster properties of interest to cosmology (e.g. incidence of cool cores, measure of mass and gas fraction) are related to observable measures of cluster relaxation.
- Therefore, we plan to:
 - Compare our ACCEPT2 mass profiles with those derived from lensing and other techniques (e.g. simultaneous fitting of X-ray, SZ and weak lensing with JACO, Mahdavi et al. 2007) to test the reliability of morphological relaxation measures in distinguishing between systems in which hydrostatic mass profiles are accurate from those in which they are not.
 - Measure f_{gas} profiles (a key cosmological quantity) out to R_{2500} , using the hydrostatic assumption, in subsamples separated according to morphology, kT and redshift, drawing on the weak-lensing comparisons in a subset of these to quantify the uncertainties in our hydrostatic mass measurements and their dependence on morphology.
- Additionally, we plan to test the role of the hot ICM in triggering star formation and/or AGN activity, by searching for signature of star formation, such as UV excess, mid-infrared (IR) emission from dust, and H α emission in the BCGs associated with the galaxy clusters in the ACCEPT2 sample and compare them with the cluster properties derived from the X-rays (e.g. core entropy, central cooling time, morphological measures of relaxation).