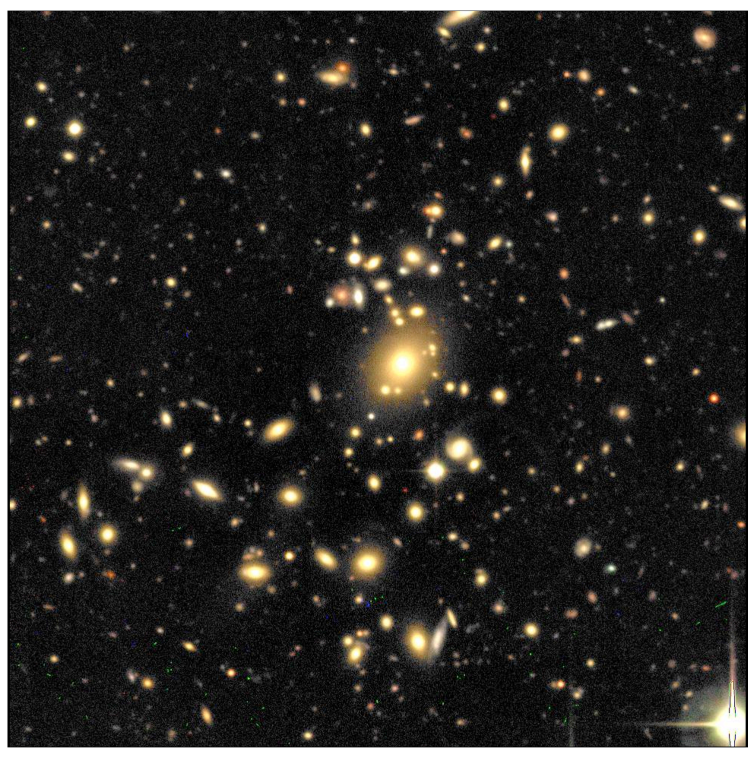

Virgo-like clusters in CFHTLS: a primer for future large surveys

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Virgo-like clusters are important for both Astrophysics and Cosmology

Galaxy groups and clusters are an ideal laboratory to study the visible matter, where the majority of the baryons are observable in the form of galaxies and hot gas. Until now the most and the least massive systems have been studied independently because a joint study requires the combination of a deep survey and a wide area. This has created an observational gap in the intermediate mass region (~10^{14} M_{sun}: Virgo-like systems), which is the sweet spot where systems are excellent probes of both physics and cosmology.

Indeed, Virgo-like systems are ideal laboratories to study feedback processes, since they play a much more important role in the global energetics of the system than in massive clusters, where gravity strongly dominates. On the other hand these systems are massive enough to be important for cosmology, especially at high redshift.

X-ray clusters in CFHTLS: a primer for eROSITA and Euclid

Virgo-size clusters will be the most common environments detected from upcoming all-sky X-ray and optical surveys, such as those that will be performed by the eROSITA/SRG and Euclid satellites. In particular eROSITA is expected to detect ~10^5 extended X-ray sources, which will be associated with intermediate mass systems (green line in Fig. 1). In the future Euclid will provide exquisite optical imaging of all these sources, enabling robust measurement of the mass of these systems via weak lensing analysis for individual systems. (orange line in Fig. 1). The synergy of these two surveys will offer the unique possibility of studying the baryonic content of clusters with enormous statistics and the best mass calibration, and to dive into the study of baryonic feedback effect such as understanding why low mass groups have a lower baryonic fraction than clusters. Furthermore those will be the only survey to enable high redshift cluster cosmology, which needs both X-ray detection and robust mass calibration.

In the light of such future perspective it is of compelling importance to start calibrating the mass range of Virgo like clusters on a prototype multi-wavelength survey such as CFHTLS. In particular Fig. 2 is showing how **this survey is ideally suited to hit the sweet spot where systems are massive enough to be studied with a reasonable observational effort and have good weak lensing masses and, at the same time, non-gravitational processes are still a significant contribution to their energetics.**

The CFHTLS cluster survey is conveniently performed over three fields of the already completed Canada-France-Hawaii Telescope Legacy Survey Wide (hereafter CFHTLS), which provides a uniquely uniform and accurate multi-wavelength deep photometry (to magnitude i~25). Recently granted X–ray observations of 50 square degrees in CFHTLS will upgrade this survey to be the state of the art for galaxy groups and clusters. Furthermore, these fields have been complemented with accurate weak lensing analysis, (by the CFHTLenS team; Waerbeke et al. in preparation) which enables us to measure accurate total masses for the X-ray detected systems. With the current data we have a robust sample of ~180 X-ray detected groups, with 0<z<1 (see poster by M. Mirkazemi for details on the detection). An additional XMM program has been proposed to quadruple the area.

First Results: calibrating the M-Lx scaling relation for galaxy groups

The CFHTLS area benefits from the available catalog of galaxy shape measurement obtained by running the LensFit code (Miller et al. 2007) and a photometric redshift catalog (Hillebrandt et al. in prep.). This allow us to robustly measure the total mass of the systems via weak lensing analysis, considering the X-ray detected clusters as lenses for the background galaxies.

Indeed only few massive systems can be detected with a good weak lensing signal-to-noise (Fig1), therefore we resort to stacking our measurements for groups sharing similar properties. We stack the weak lensing signal for the clusters divided in 4 bins according to their X-ray luminosity ($L_X E(z)^{-1}$), as this quantity is directly observable and traces the mass of the systems.

In Figure 3 we show the preliminary scaling relation between L_X and M_{200} obtained for the CFHTLS sample and compared to other samples of lower and higher mass systems such as COSMOS (Leathaud et al. 2011), SDSS (Rykoff et al. 2008) and 160 square degrees ROSAT Survey (Hoekstra et al. 2011). This plot shows the optimal complementarity of the CFHTLS mass range to the samples available in the literature, covering an intermediate range of mass which has been sparsely sampled by both surveys focused on groups and clusters. Further analysis is currently ongoing.

References

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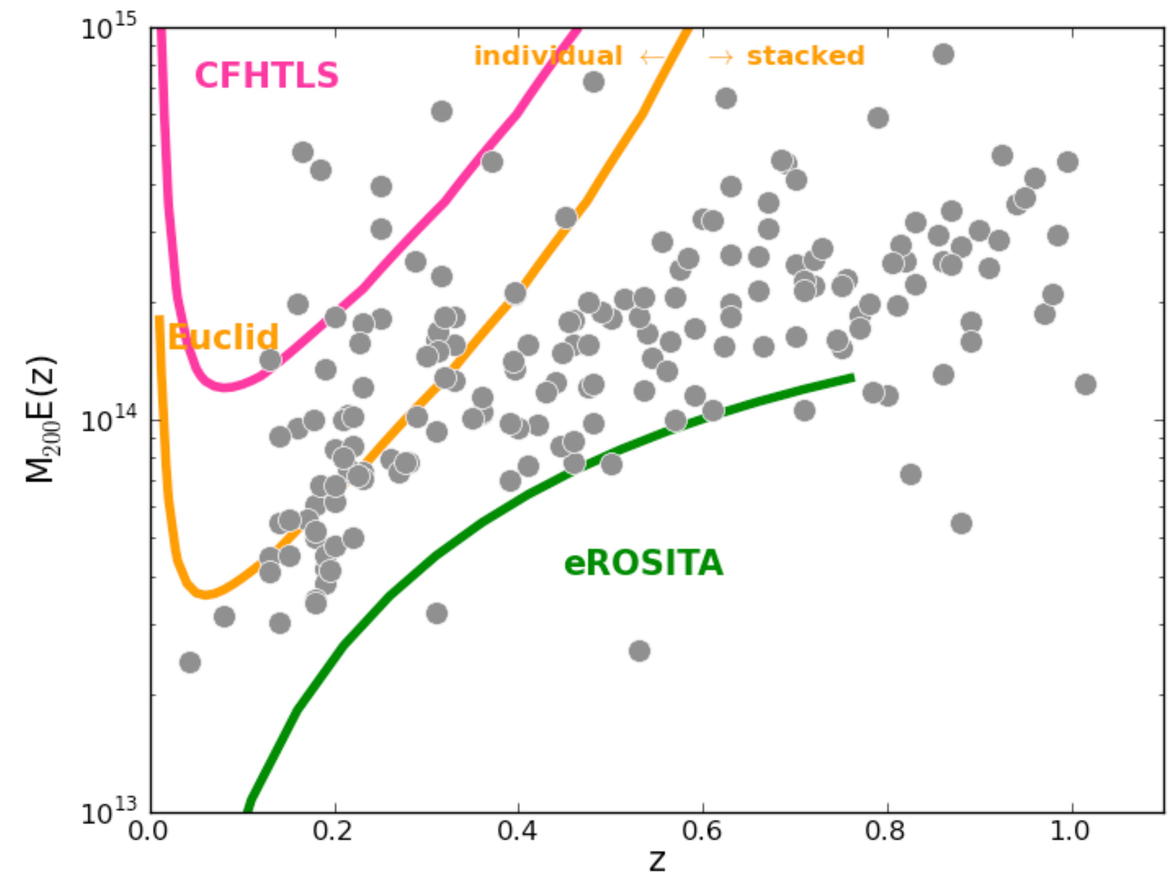

Figure 1: Mass-redshift distribution for CFHTLS cluster sample (grey circles). Points above the magenta line are detected at 3 sigma with the actual CFHTLS weak lensing data. Points above the orange line will be detected at better than 2σ with Euclid. Arrows indicated where analysis of individual or stacked systems will be possible.The green curve is the mass detection limit for eROSITA corresponding to a flux limit of 10^{14} ergs/s/cm^2.

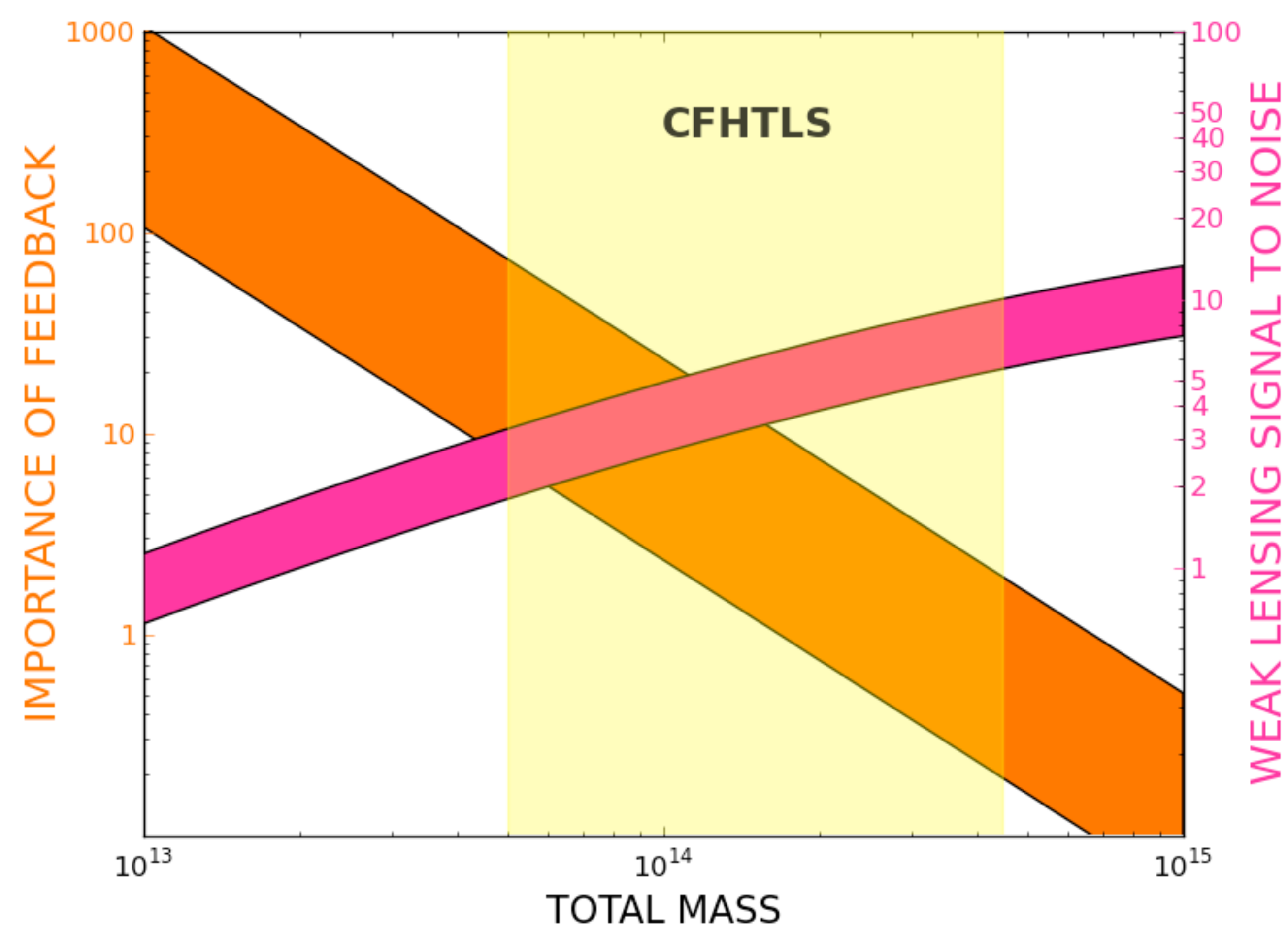

Figure 2: the importance of feedback (in orange; defined as ratio between gravitational energy and radio galaxy feedback) increases in systems of lower mass. The signal-to-noise of weak lensing observations (in magenta) determines how well we can measure the total mass of the system (and therefore its quality as a probe of cosmology) and increases for systems of larger mass. These opposite behaviours define a sweet spot in the mass range at $10^{14}M_\odot$, where feedback is important (feedback>>1) and the mass of individual systems is measurable with weak–lensing (signal-to-noise>>1) . With the CFHTLS survey we can study systems exactly in this mass range (yellow shaded area).

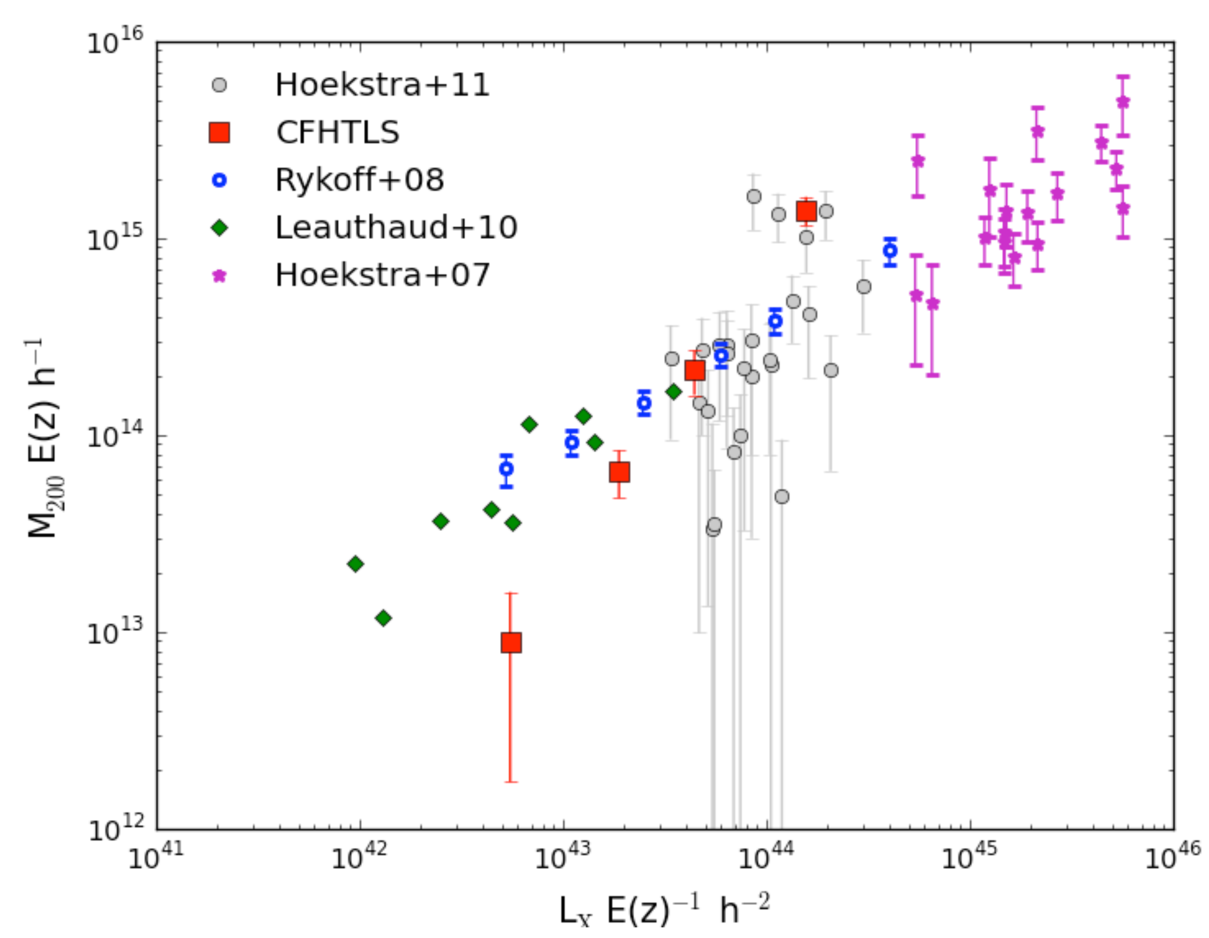

Figure 3: M_{200}-L_x relation for X-ray detected clusters in CFHTLS (red squares) compared to the results from other surveys in the literature.