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Optical and near-infrared follow-up of the XMM Cluster Archive Super Survey (X-CLASS): Preparing for eRosita

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The XMM Cluster Archive Super Survey (X-CLASS) is a serendipitous, X-ray selected galaxy cluster catalogue, containing 850 clusters, extracted from 2774 observations from the XMM archive following the methodology of the XMM-LSS/XXL. Here, I present details of an optical and near-infrared follow-up of 160 members of the sample with the simultaneous, seven-channel (g'r'i'z'JHK$_s$) imager GROND on the MPG 2.2m telescope at La Silla. These clusters form a part of the extended X-CLASS cosmological sample, which benefits from a uniquely well-controlled selection function over 90 deg^2. GROND provides an efficient tool for the identification of red sequence member galaxies and determination of photometric redshifts. This in turn allows for the characterisation of the clusters for future cosmological analyses.These observations will assist with the refining of observational and analytical strategies for future eRosita [Predehl et. al 2010] cluster studies, as the X-CLASS sample is a good representation of the expected eRosita cluster catalogue (launch in 2015).

Introduction

Galaxy clusters trace massive potential wells in the cosmic web and are excellent probes of the growth of structures in the Universe. Their X-ray emission provides us with important mass-related quantities, provided an accurate redshift is available. X-ray and optical data must thus be combined in order to fully exploit the cosmological signal of cluster surveys.

The combination of GROND's field-of-view and good sensitivity in 7 bands makes it an ideal tool for the rapid followup of X-ray selected galaxy clusters allowing for:

- Optical confirmation of X-ray identified clusters;
- Identification of red-sequence galaxy cluster members;
- Robust determination of photometric redshifts;
- Immediate characterisation of the cluster for future analyses.

The multi-band photometry of GROND will also allow for the analysis of the stellar mass and star formation rates of galaxies, derived from SED fitting [Maraston et al. (2006)], in relation to the X-ray properties of their host clusters over a wide range of redshifts.

Sample characteristics

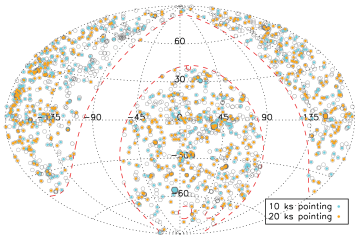


Fig. 1a: The distribution of the XMM archival observations used for creating this sample. Observations shorter than 10ks (open circles) where not considered for the X-CLASS catalogue. The other pointings are truncated to 10ks (blue points) and 20ks (gold points).

The observations were selected from the XMM Science Archive system with the criteria: (1) high galactic altitude ($|b| \geq 20^{\circ}$); (2) total exposure > 5 ks; (3) all three detectors in imaging mode and at least one of them in full-frame mode; (4) pointing centre away from the SMC, LMC and M31; (5) public data as of 26 May 2010. The observations are processed in an identical manner to the XMM-LSS [Pacaud et al. 2006] yielding a total of 845 C1 cluster candidates.

In order to perform cosmological analysis, a higher signal-to-noise subsample is extracted by excluding pointings with a high background, with one or more detectors not in full-frame mode and those centred on nearby luminous clusters. Further, only sources with an extent likelihood > 40 and an extent > 5 arcsec are selected giving a subsample of 347 C1$^+$ cluster candidates. For more details see Clerc et al. 2012b.

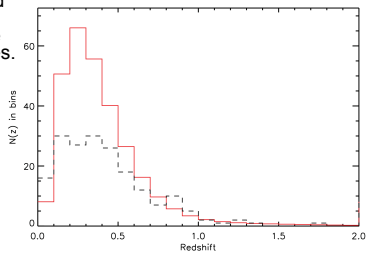
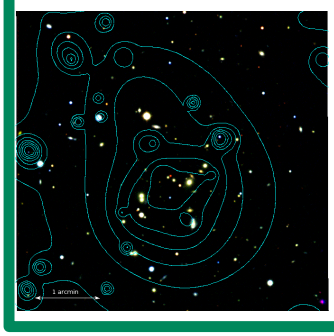


Fig. 1b: The predicted redshift distribution of the X-CLASS cosmological sample (red line) and the distribution of catalogue members with redshifts already known from literature (black dashed line).

Cluster Observations



Cluster candidates are visually inspected with imaging from DSS and classified as having a redshift either < or > than 0.3. Those clusters classified as nearby are observed for 8 and the more distant observed for 20 minutes. Only clusters with declination < +20° are accessible with GROND leaving a sample of 160 clusters. A pipeline for cluster member identification and photometric redshift determination is currently under construction. Sources detected from a preliminary investigation of XCLASS2305 making use of the color-magnitude diagram (Fig. 3) are shown in the left panel of Fig. 2. To date, 150/160 clusters have been observed with GROND with the sample due for completion in August 2014. A program to follow up an additional 112 cluster candidates detected from 900 new XMM archival pointings (X-CLASS II) is currently underway.

Fig. 2: Typical *gri* composite images of XCLASS2305 (top, possibly an extremely luminous cluster at z~0.7; cluster members circled), XCLASS1882 (bottom, confirmed at z=0.22) are shown with X-ray contours from XMM observations.

Outlooks

We are currently working on obtaining a robust photometric calibration and cluster member identification pipeline. Once the photometric redshifts have been computed, by making use of colour-magnitude diagrams and SED template fitting, we will be in position to compute X-ray luminosities, temperatures and masses of the entire cosmological sample. From there we will implement the ***z***-CR-HR method (see poster of N. Clerc, Clerc et. al 2012a) for cosmological analysis, making simultaneous use of the X-ray, optical and near-IR data.

In addition to providing a uniquely, well-controlled selection of galaxy clusters with the potential for constrain cosmological parameters to a high significance, these observations will be a useful tool to refine the techniques for future eRosita cluster followup as these sources are similar in flux and size to those expected from eRosita.

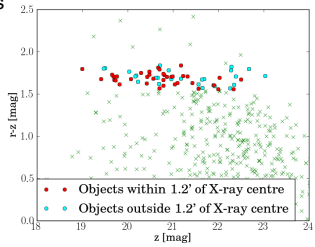


Fig. 3: Colour-magnitude diagram of XCLASS2305. The position of the red sequence galaxy cluster members indicates a redshift of z~0.7 which would make this on the most X-ray luminous ($L_X = 8 \times 10^{44}$ erg/s) high ***z*** clusters known.

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