Max Planck Institute for Extraterrestrial Physics

The X-ray – SZE – Optical – NIR Galaxy Cluster Survey

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Introduction

Detection and analysis of clusters of galaxies via the Sunyaev-Zel'dovich effect (SZE) holds large potential to provide powerful tests of cosmological models and to study the nature of Dark Energy. In order to utilize this potential, it is necessary to have a deep understanding of the SZ selection function and calibration. To this end, the three major SZ experiments, SPT, APEX and ACT, will focus their initial efforts into a common test region.

However, to gain a very precise understanding of the SZE-cluster survey selection function and to secure the best information on global physical parameters of the clusters, there is also a need for X-ray observations, which still provide the best understood way of surveying for clusters.

For these reasons we are leading an combined X-ray/SZ/optical/NIR survey in a 6 deg² area within the SZ test region. The observing time has been granted in the framework of a *XMM-Newton* Large Observing Programme as one of the *XMM-Newton* legacy projects.

Survey Characteristics

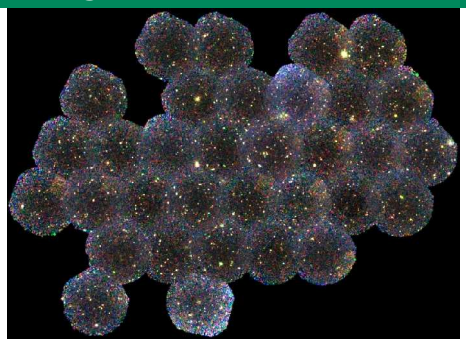

Fig. 1: An RGB color image of the survey field in the the three highlighted bands. Displayed are the 33 currently available pointings of *XMM-Newton* which were not significantly affected by soft proton flares. The image was created by coadding the data from PN and both MOS cameras without background subtraction and smoothed with an 8" gaussian kernel.

The X-ray part of the survey consists of 42 *XMM-Newton* pointings with 10 ks exposures covering a 6 deg² field in the common test area of the SZ experiments. The exposure times were selected to roughly match the number of detected clusters with the SZE surveys. Flux limits of the observations in the 0.5 – 2 keV band are ~ 6.5 10^{-15} erg cm^{-2} s^{-1} for point sources and ~ 1.0 10^{-14} erg cm^{-2} s^{-1} for extended sources. Up to now, data for 41 of the 42 fields was delivered. 8 fields were completely lost due to soft proton flaring.

In addition to the overlap with all three SZE surveys our X-ray observations are complemented by a multi-band *griz* imaging survey (Blanco Cosmology Survey - BCS, P.I.: J. Mohr) on the 4m-class telescope BLANCO at Cerro Tololo, and by imaging with IRAC, on the Spitzer space observatory (P.I.: A. Stanford). The combined optical-NIR data set will allow us to obtain accurate photometric redshifts for our X-ray detected clusters.

Cluster Candidates

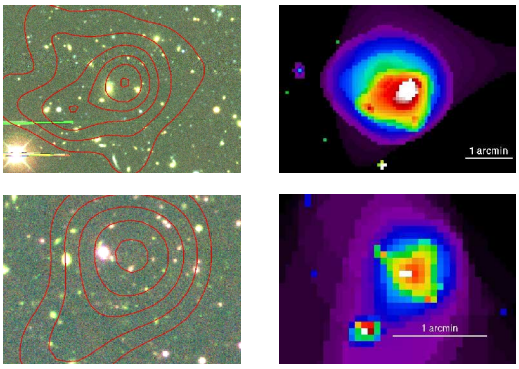

Fig. 2: Two examples of X-ray detected cluster candidates. *Left panels:* color image of the *gri* bands from the BCS survey. X-ray contours are shown in red. *Right panels:* wavelet reconstruction of the X-ray image of the clusters in the 0.35 – 2.4 keV band.

Source detection was carried out on 33 fields and yielded ~2000 source candidates in total, out of which 101 sources have been flagged as extended. After cross-correlating the preliminary source list with optical data we expect to find ~60 - 70 real clusters. Good selection control will be possible for roughly half of these clusters. We will provide X-ray counterparts of 100% of SZ selected clusters with z < 1 and > 50% counterparts for z > 1.

Outlooks

With our *XMM-Newton* survey we are bringing together all established techniques for cluster selection with the upcoming SZE technique in a single region of the sky, setting thus the foundation for future, larger solid-angle studies to achieve high precision cosmological constraints.

The survey will allow for first calibration and provide X-ray physical parameters of the detected clusters for the SZE observations. Rich coverage of the fields in different wavelength domains enables an unprecedented intercomparison of the results.

Additional science from the survey includes cluster evolution and cosmological modeling, detection and studying of AGN and their clustering properties.

We hope that future *XMM-Newton* AOs will allow us to extend the X-ray survey area to 12.5 deg². This next step is essential in order to fully exploit the available data in other wavelengths and allow competitive cosmological constraints to be established. **Doubling the area will significantly increase the overlap of X-ray and SZE detected clusters (especially for z > 1 cases), enabling high precision calibration of the seletion functions.**

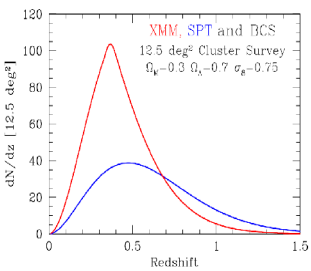

Fig. 3: Expected number of detected clusters for SPT and for XMM in the proposed 12.5 deg² survey region in redshift bins of z = 0.1, we count only clusters with M > 10^{14} M for SPT.

For further information, please contact: rsuhada@mpe.mpg.de