Cosmological Implications from the eROSITA All-Sky Survey

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Motivation – Galaxy Clusters and Cosmology

The evolution of the Universe and thus also the cosmological parameters, including the nature of **dark energy**, are imprinted in the *Large Scale Structure (LSS)* of the Universe. This evolution is especially traced by the distribution of galaxy clusters, which is for example expressed by the *halo mass function*. This functions expresses the number density of dark matter haloes in dependence on their mass and redshift.

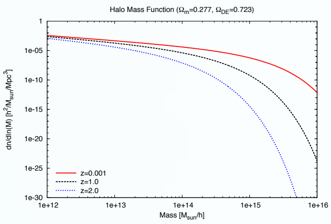


Figure 1: Halo mass function for a WMAP5 cosmology based on the theoretical function by Tinker et al., 2008, and the transfer function given by the CAMB-algorithm (Seljak & Zaldarriaga, 1996). The shape of this function strongly depends on the underlying cosmology.

Galaxy cluster redshifts of the highest precisions are obtained in optical spectroscopic observations. Their halo masses can indirectly be inferred from X-ray observations. First mass estimates can be based on X-ray temperatures or luminosities, which are imprinted in the cluster spectrum, and the application of scaling relations. Thus, analysing a large sample of galaxy cluster spectra enables to trace the LSS and thus to obtain knowledge on the properties of dark energy.

The eROSITA-Mission

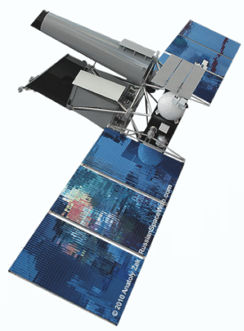


Figure 2: The eROSITA instrument on SRG. Credit: *MPE*

Facts on eROSITA:

- German X-ray instrument aboard the Russian satellite *Spektrum Roentgen Gamma (SRG)* (Predehl et al. 2010)
- Expected launch date: 2015/16 to a L2 orbit
- Energy coverage: (0.1 - 8.0) keV
- 4 years of all-sky surveys followed by 3 years of pointed observations
- Detection of around 100,000 clusters of galaxies (e.g. Pillepich et al. 2012; Merloni et al. 2012)

Main science driver: studying the nature of dark energy

Cosmological Predictions: (Pillepich et al. 2012, Merloni et al. 2012)

- Δw_0= 0.026 (for w_a = 0)
- Δw_a = 0.206

Introduction to this Work

The aim of our work is to forecast the constraints that the up-coming *eROSITA* instrument will place on the cosmological parameters, especially on the nature of dark energy. These simulations are based on the distribution of galaxy clusters and on how well this new instrument will be able to determine the individual clusters properties. We first predict the precision for observed cluster temperatures and redshifts from *eROSITA* data only. Additionally, we quantify possible systematic errors in the analysis of the data. In a second step, we prepare cosmological forecasts. Eventually, we will then implement the afore obtained details on the detectability of cluster temperatures into these simulations for a realistic assessment of the observational strength of *eROSITA*.

First Results: Examples (Borm et al. 2014, arXiv:1404.5312)

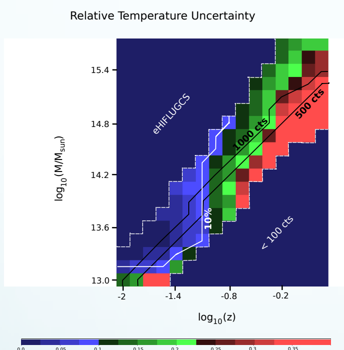
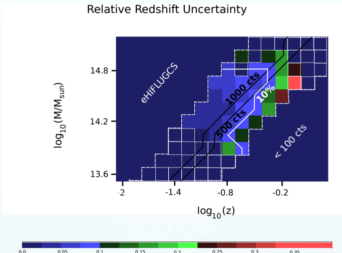


Figure 3 & 4: The colours of the pixels present the relative uncertainties, ΔT/T or Δz/(1+z). The white framed pixels indicate clusters with large numbers of catastrophic failures in the spectral fit. The simulation is generated for t_{exp}=1.6 ks.



We predict the precision of the cluster temperatures and redshifts obtained from the *eROSITA* data only, based on a spectral analysis and the application of the scaling relation by Reichert et al., 2011(Figs. 3 & 4). Precise temperatures with a relative uncertainty below 10% will be available for clusters up to z ~ 0.08. The displayed region adds up to newly obtained temperatures for 1,700 clusters of galaxies in addition to the already available *eHIFLUGCS* data. A good estimate on the X-ray redshift will be available for clusters up to redshifts of z~0.45. According to this, redshift estimates will be available for 23,000 clusters.

For the presented simulations, the bias in the cluster properties is negligible for those clusters with precise temperature or redshift estimates.

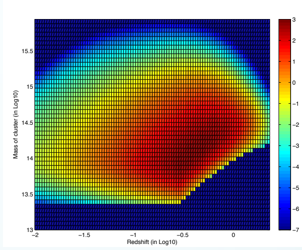


Figure 5: Probability distribution of the number of clusters given in Log_{10} observed by *eROSITA*.

Towards Cosmology with *eROSITA*

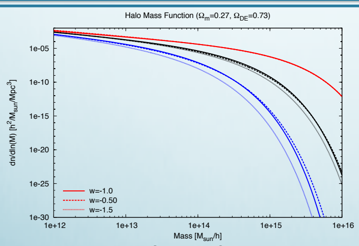


Figure 6: Halo mass function for a WMAP5 cosmology, different equations of state *w* of dark energy and redshifts z = 0.01 (red), z = 1.0 (black), z = 2.0 (blue).

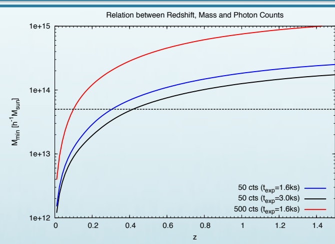


Figure 7: Observed number of photons with the *eROSITA* instrument in dependence on the cluster mass and redshift. A mass-cut is defined at $5{*}10^{13}$ h^{-1} $M_\odot$. (compare also Pillepich et al. 2012)

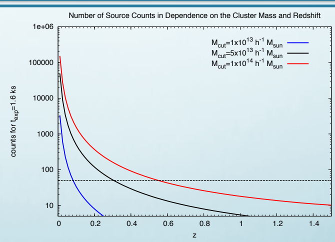


Figure 8: We introduce a limit of 50 photons for a cluster to be detected by the instrument (dashed line). The plot shows the observation limit for individual masses. (compare also Pillepich et al. 2012)

Outlook

Based on the halo mass function for the *eROSITA* instrument, we aim to run MCMC simulations (CosmoMC) to estimate the constraints on the different cosmological parameters. Additionally, we want to investigate the precision of the nature of dark energy in dependence on the precision of the observed cluster redshifts. This information is essential for planning optical follow-up observations to determine precise redshifts of *eROSITA* clusters. Eventually, we will include the above presented temperature information in the cosmological forecasts as well as the knowledge of weak lensing masses for a sample of clusters. These additional information will tighten the constraints on the cosmological parameters further and will allow for a realistic assessment of the observational strength of the *eROSITA* instrument.

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