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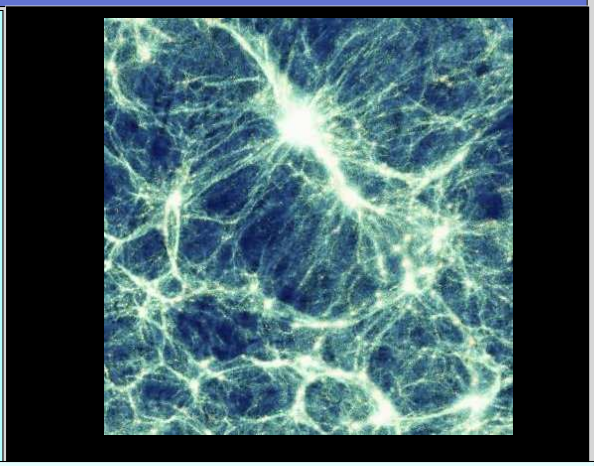
Search for X-ray signatures of the cosmic web in superclusters

O. Madej[1,2], *N. Werner*[1]

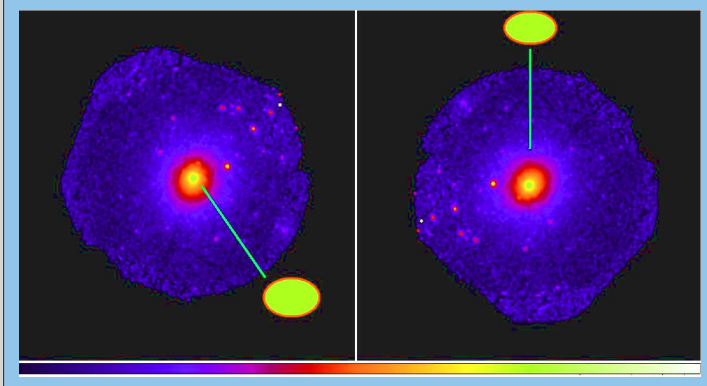
[1] SRON, Netherlands Institute for Space Research, The Netherlands
[2] Astronomical Institute, University of Wroclaw, Poland

Introduction

According to the standard theory of structure formation, the spatial distribution of matter in the Universe evolved from small perturbations in the primordial density field into complex structure of sheets and filaments with clusters of galaxies at the intersections of this filamentary structure. The filaments have been identified in optical surveys of galaxies already 30 years ago (Joeveer et al. 1978) but evidence of the cosmic web from X-ray observations was for a long time weak and controversial.
We search for signs of the cosmic web by combining XMM-Newton data of cluster of galaxies within superclusters obtained over the last 10 years. We report the initial results of our work in progress.

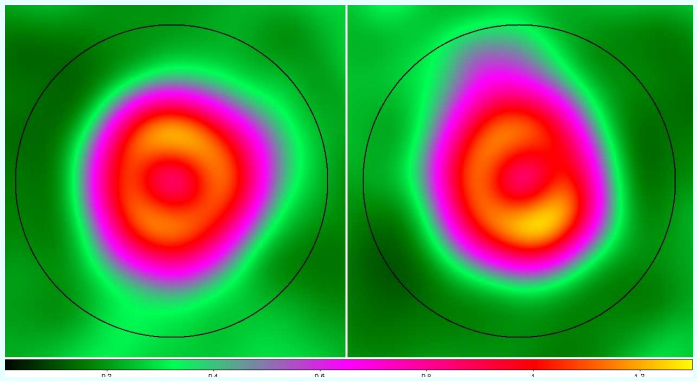


Method



Based on the ROSAT-ESO Flux Limited X-ray (REFLEX) Galaxy Cluster Survey, we selected all X-ray bright clusters within superclusters observed with XMM-Newton. Our final sample, after excluding peculiar clusters like mergers or those which had groups of galaxies present within the field of view, contains **46 clusters within 37 superclusters with a total exposure time of 1.1 Ms (13 days)**. We co-added the images in 0.5-2.0 keV band from all instruments. The background was subtracted and the images were corrected for vignetting. We scaled the images, so that every pixel on every image corresponds to the same fraction of r_{500}. We determined the r_{500} for each cluster based on their EPIC temperatures using the formula $r_{500} = 0.45\mathrm{Mpc} \times \sqrt{\mathrm{kT/keV}}\mathrm{h}_{70}^{-1}\mathrm{h(z)}^{-1}$ (Finoguenov et al. 2005). Using the REFLEX catalogue, we selected the nearest neighbour cluster within the same supercluster. We rotated every image so that the nearest neighbour of the cluster in the image would be at same position angle - the top (see the Figure above). Then we co-added all the images into a single image. We did the same with the images which were not rotated and so in which the direction to the nearest neighbour is at a random position angle.

Results



In the left panel we show the image after co-adding all the cluster images scaled to the same fraction of r_{500} with their nearest neighbour at a random position angle. In the right panel we show another co-added image, where the closest neighbour of each cluster is at the same position - at the top. For both images, we subtracted a radially symmetric surface brightness profile and used wavelet decomposition to identify structures. The black circle indicates the radius of r_{500}.
We detect a substructure in the expected direction. The size of the substructure is approximately r_{500}. It is probably due to a different density profile toward the filament connecting the cluster with its closest neighbour.

References:

Finoguenov, et al. 2005,AA 442, 827-839
Joeveer, et al. 1978, MNRAS,185,357-370

Acknowledgements:

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