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The XMM Large Scale Structure (XMM-LSS) Survey: X-ray analysis and first results

A. M. Read ⋆

Dept. of Physics and Astronomy, Leicester University, Leicester LE1 7RH, U.K.

Abstract. Thanks to its unprecedented sensitivity and large field of view, *XMM* occupies a leading position as a survey instrument. The *XMM*-LSS survey is a medium-deep large-area X-ray survey, and greatly extends the cosmological tests attempted using earlier studies. While a wealth of complementary multiwavelength studies are taking place, I concentrate here on the *XMM*-EPIC data, describing aspects of the X-ray pipeline and analysis, and selected first results, including the deepest wide-angle X-ray image of the cosmos to date.

Key words. X-rays – Large Scale Structure – Clusters of Galaxies

1. Survey motivation and design

An *XMM*-EPIC medium-deep large-area X-ray survey - the *XMM* Large Scale Structure survey (*XMM*-LSS) (Pierre et al. 2003) - has been designed to extend earlier ROSAT cosmological tests (Böhringer et al. 2001) to two redshift bins between $0<z<1$, while maintaining a high precision. The evolutionary study of the cluster-cluster correlation function and of the cluster number density has constrained the survey design: an equatorial mosaic of 10 ks pointings, separated by 20', and covering $8° \times 8°$, giving a sensitivity of $\sim 3 \times 10^{-15}$ erg cm^{-2} s^{-1} in the 0.5–2 keV band, and yielding >800 clusters and many more AGN with a space density of $\sim$250 deg^{-2}. The survey will be able, for the first time, to map out the the evolution of the LSS of the universe out to $z\sim1$ with both the galaxy cluster and the QSO populations.

Several other major surveys from the radio to the UV wavebands are currently being undertaken over the LSS sky region, including the CFHTLS weak lensing and the AMiBA SZ surveys, Magellan and VLT/FORS2 spectroscopic surveys, and CTIO, UKIRT, VLA, OCRA, SIRTF and GALEX studies (plus others). Constraints of space allow only a discussion here of the *XMM*-EPIC data. The wide scope of the LSS survey has necessitated the assemblage of a large consortium, and the project is presented in detail at `http://vela.astro.ulg.ac.be/themes/spatial/xmm/LSS/index_e.html`.

Send offprint requests to: A. M. Read
⋆ on behalf of the LSS consortium
Correspondence to: Dept. of Physics and Astronomy, Leicester University, Leicester LE1 7RH, U.K.

2. X-ray analysis and first results

Fig. 1 shows a mosaic of the first 15 *XMM*-LSS fields. The improvement over the RASS is very striking, with a source density of $\sim$300 deg^{-2} in the 0.5-2 keV band. Supersoft and very hard sources are seen, as well as sources covering

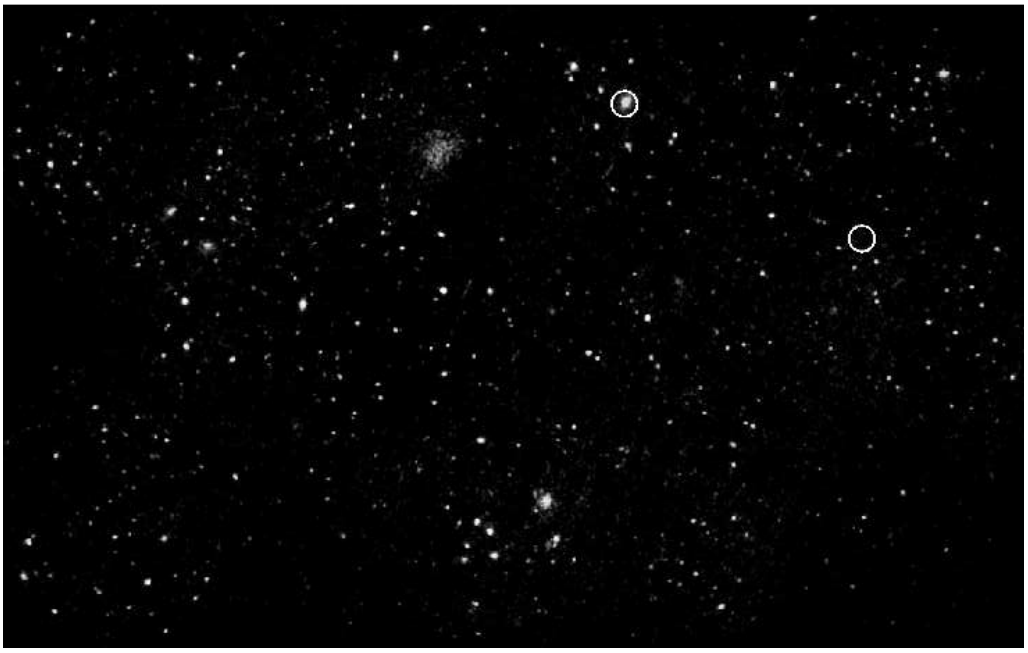

Fig. 1. Deepest large-scale view of the X-ray sky. 1.6 deg^2 mosaic of the first 15 10 ks all-EPIC *XMM*-LSS fields. Circles indicate sources found in the RASS (the brightest source is a star; HD14938). (3-colour image at http://vela.astro.ulg.ac.be/themes/spatial/xmm/LSS/First/FMos/).

a wide range in extent, all indicating the scientific potential of the survey. The large, extended feature to the north (*XMM*UJ022540-031111) is associated with a z~0.3 merging cluster, the single X-ray peak (hotter than the surrounding cluster emission) located *between* the two galaxy subclumps.

The *XMM*-LSS pipeline is based on a 3-stage filtering/detection/measurement process. Photon images are wavelet-filtered (in counts, to preserve Poisson statistics) for each EPIC instrument separately. The three exposure-corrected images are then summed for a first Sextractor detection step, the output being fed into a final SAS-emldetect step. Tests involving dedicated detailed simulations, incorporating all instrumental effects, background and both point and extended sources, show that most, if not all (T>4 keV) clusters within z~1, and the brightest clusters up to z~2 (if they exist) should be detected in a 10 ks exposure. Further, a very small rate (<1 per pointing) of spurious detections is expected.

Initial results, described in detail in Pierre et al. (2003), Valtchanov et al. (2003) and also Willis et al. & Andreon et al. (in preparation), indicate that we are detecting, as expected (for a ΛCDM cosmology), ~15+ extended source per square degree, with counterparts in the optical and in the NIR, and we are observing clusters beyond z>1. We see that a 10 ks *XMM* exposure and 2h on the VLT allows a kT (to ±1 keV) and σ measurement out to z~0.8. Many intermediate mass systems are being uncovered, as well as relaxed, merging and collapsing clusters, and many AGN.

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