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Radio relics in X-ray galaxy clusters: NVSS and NORAS/REFLEX and the case for LOFAR and eROSITA

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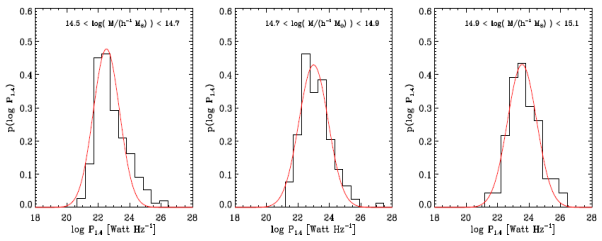
Motivation

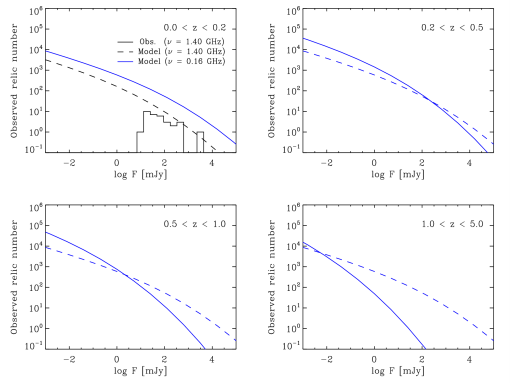
Upcoming radio surveys such as LOFAR are expected to discover a large number of new radio relic sources. We investigate the abundance and distribution of relics, i.e. diffuse radio emission coming from the periphery of galaxy clusters which is believed to trace shock waves induced by cluster mergers, both in simulated and observed galaxy cluster samples.

We determine how the radio power of relics is related with cluster mass, redshift and frequency by a synthetic galaxy cluster sample extracted from the MareNostrum Universe (Gottlöber & Yepes 2007), a non-radiative SPH cosmological simulation of 500 h^{-1} Mpc on a side, assuming diffusive shock acceleration for relativistic electrons present in merger shocks.



The histograms show the *radio power probability density* for relics at z=0 and observing frequency ν=1.4 GHz for three different cluster mass ranges. Higher mass clusters tend to host brighter relics. The red solid lines are best-fitting log-normal curves.

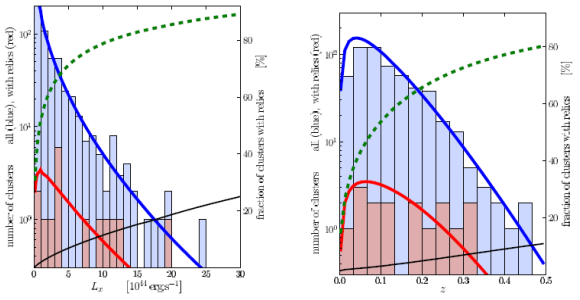
Observed relic flux distributions



The figure shows the model predictions for the observed relic number per logarithmic flux interval in different redshift bins. The local NVSS relic sample was compiled by Nuza et al. (2011; submitted). The blue solid line corresponds to the prediction for ν=160 MHz, which is a typical LOFAR observing frequency.

Clusters hosting radio relics: X-ray luminosity and redshift distributions

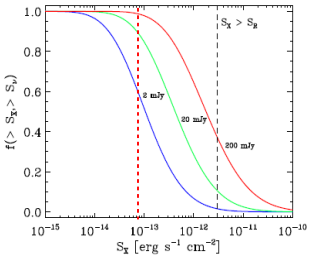
van Weeren et al. (2011) selected 544 clusters from the NORAS and REFLEX (Böhringer et al. 2000, 2004) cluster samples with an X-ray flux above 3 x 10^{-12} erg s^{-1} cm^{-2}. They show that 16 out of the 544 clusters of the combined list contain at least one radio relic and found evidence for an increase of the fraction of clusters which host relics with cluster X-ray luminosity and redshift.



Luminosity (left panel) and redshift (right panel) distributions of X-ray clusters in the NORAS/REFLEX sample with and without NVSS radio relics (red and blue histograms respectively). Blue and red solid lines show the distributions expected in our model while the black solid line shows the fraction of clusters with relics. The green dashed lines show the expected fraction of clusters with relics for the NORAS sample in the upcoming LOFAR-Tier 1-120 Mhz survey.

The LOFAR case: requirements for future X-ray cluster samples

We compute the fraction of relics with 3 different radio fluxes which are hosted in clusters above a given X-ray flux. The figure shows the case for the LOFAR-Tier 1-120 MHz radio survey and X-ray flux in the 0.1-2.4 keV band.



The cross-correlation between the radio relic and X-ray cluster samples is crucial for relic identification. Since LOFAR is expected to detect hundreds of radio relic candidates as a function of redshift new X-ray galaxy cluster catalogs are needed to confirm their nature. To identify even the brightest relics (~200 mJy) deeper X-ray catalogues than currently available are needed. An appreciable fraction of the clusters hosting relics with moderate fluxes would be detected with an X-ray flux limit close to that of the forthcoming eROSITA satellite in the soft X-ray band (S_X ~ 10^{-13} erg s^{-1} cm^{-2}; red dashed line).