An SZ take on Cluster Radio Haloes

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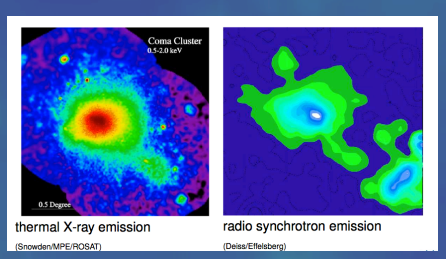
Giant radio haloes

Giant radio haloes in galaxy clusters are the primary evidence for the existence of relativistic particles (cosmic rays) and magnetic fields over Mpc scale.

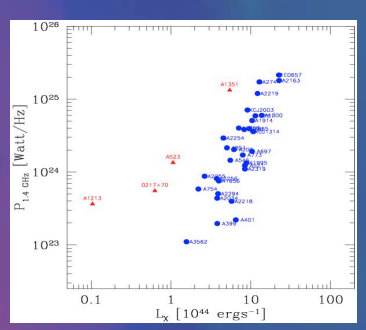


Left: Example of a giant radio halo, as seen in the Coma cluster.

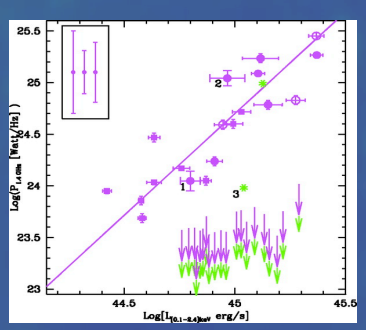
We present the first correlation results for radio haloes with the thermal Sunyaev-Zel'dovich (SZ) effect, towards a better understanding of the global properties of radio halo clusters.

X-ray correlation / bi-modality

The correlation with X-ray luminosity is a definitive one, but there are several outliers (see figure from Giovannini et al. 2011 below). Also not all mergers host a radio halo.



Giovannini et al. 2011



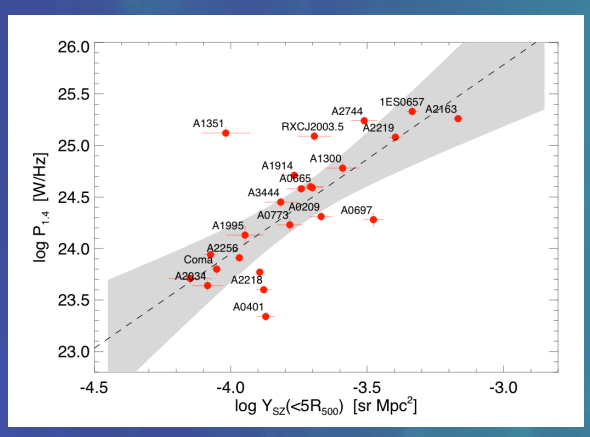
Brunetti et al. 2007

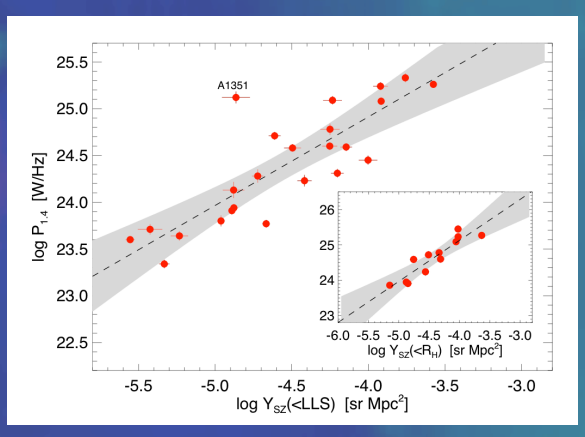
More importantly, X-ray selection reveals two distinct class of objects: those hosting powerful radio haloes, and those which are "radio quiet".

We explore the impact of selection based on the SZ signal on this thermal/non-thermal correlation and the "bi-modality"

Radio-SZ correlation results

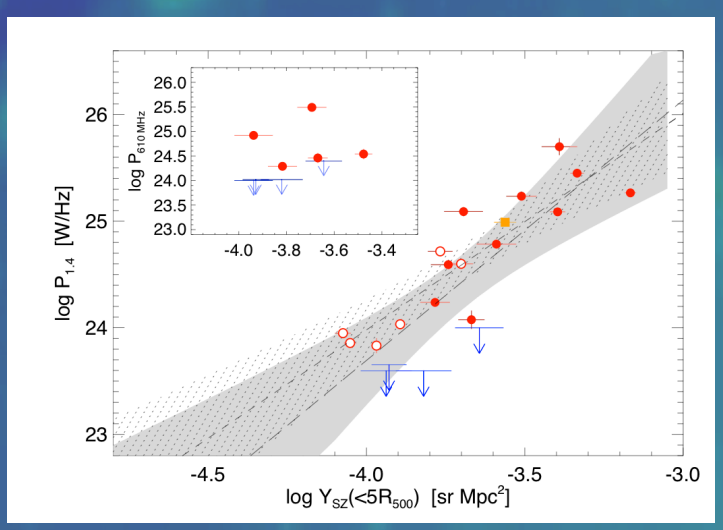
We use published radio halo data from the literature, and the *Planck* Early Science SZ catalog (Planck collaboration 2011), to obtain results for radio-SZ correlation.
As can be expected from the well-established radio/X-ray correlation, we find a clear correspondence between the thermal SZ signal and non-thermal radio.

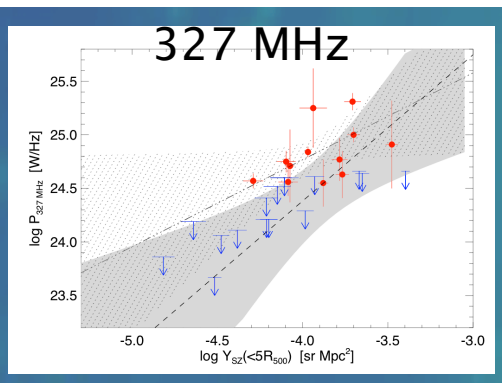




No strong bi-modal division

But we do not find any strong bi-modal division split between radio halo and radio quiet objects. The halo non-detection clusters are generally under-luminous, but their occurrence in the *Planck* catalog is much less frequent as compared to X-ray selected samples. As such we can not conclude whether the bi-modality is weaker or non-existent.





We argue that the observed bi-modality in the X-ray selected samples is an artifact of including low-mass / high-L_X cool core clusters, which are "radio quiet". Consequently, the SZ signal is a better estimator of radio halo activity in clusters.

Interpretation

From the measured radio-SZ correlation coefficient and the self-similarity in cluster pressure profiles, we derive simple mass scaling for the radio halo power:

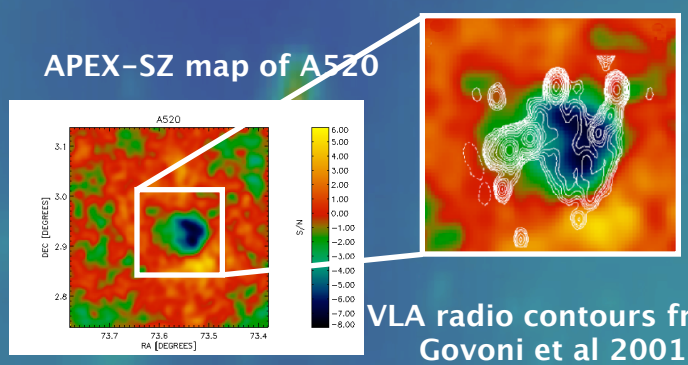
$$P_{1.4} \propto M_H^{2.1\pm0.3} \propto M_{\rm vir}^{3.4\pm0.4}$$

The scaling with the total virial mass is a new result, distinct from previous X-ray analyses, and might be helpful for estimating radio halo statistics from simulations.

On-going work

We are working to obtain further confirmation of the above results with a complete SZ selected cluster sample, both from new observations and from stacking of shallow survey data.

APEX-SZ map of A520



VLA radio contours from Govoni et al 2001

We are also finding interesting morphological similarities between radio and SZ maps for a few well-known clusters hosting radio haloes. Above is one example where the SZ data have been obtained from the APEX-SZ experiment.

Background image: SZ + CMB simulation by Zhang, Pen, Wang 2002