MAGNETICUM

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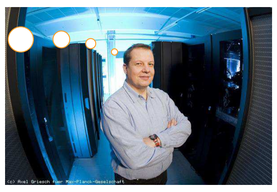
Klaus Dolag, dolag@usm.uni-muenchen.de
Ludwig-Maximilians-Universität München, Fakultät für Physik, USM, Scheinerstr. 1, 81679 München, Germany
and Alexandro Saro (USM); Eiichiro Komatsu, Rashid Sunyaev (MPA)



Predicting the SZ Signal of the Universe

The role of cosmological, hydro-dynamical simulations

The thermal SZ power spectrum

*The Magneticum Pathfinder (**www.magneticum.org**) cosmological, hydro-dynamical simulation ($896h^{-1}$Mpc)^3 follows in detail the thermal and chemical evolution of the ICM as well as the evolution of super-massive black holes and their associated feedback processes. We demonstrate that assuming cosmological parameters inferred from the CMB, the thermal SZ power spectrum as observed by PLANCK is well matched by the deep light-cones constructed from these cosmological simulations. The thermal SZ prediction from the full SZ maps are significantly exceeding previous templates at large l (e.g., $l > 1000$) and therefore predict a significantly larger contribution to the signal at $l = 3000$ compared to previous findings. The excess of positive values within the probability distribution of the thermal SZ signal within the simulated light-cone agrees with the one seen by PLANCK. This excess signal follows a power law shape with an index of roughly 2.2. The bulk of the thermal SZ signal originates from clusters and groups which form between $z = 0$ and $z \approx 2$ where at high redshift ($z > 1$) significant part of the signal originates from proto-cluster regions, which are not yet virialized. The simulation predicts a mean fluctuating Compton Y value of 1.18×10^{-6}, with a remaining contribution of almost 5×10^{-7} when removing contribution from halos above a virial mass of $10^{13} M_\odot/h$.*

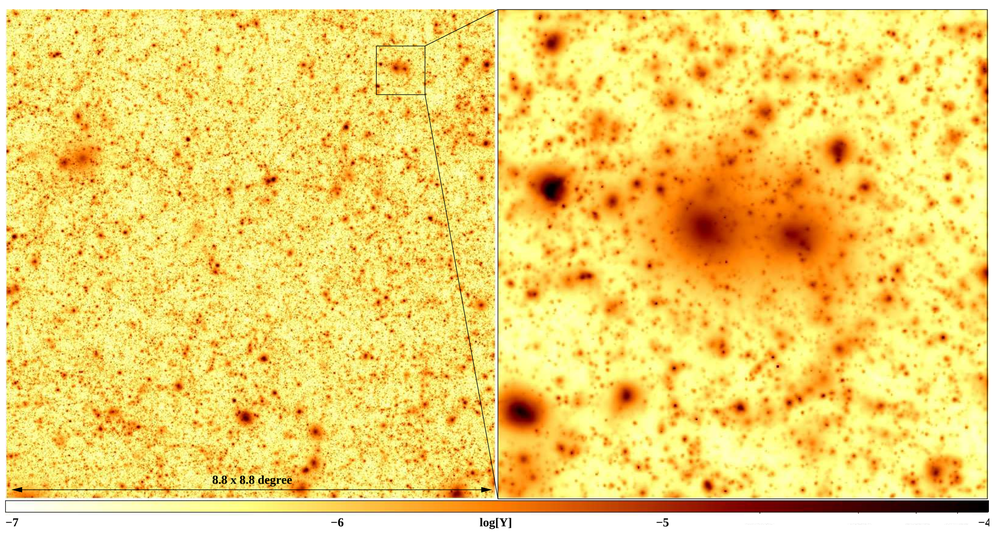


Figure 1: *The thermal SZ signal from the deep (out to z = 5.2), 8.8 × 8.8 degree wide light-cone obtained from the* Magneticum Pathfinder *simulation. The right panel shows a zoom onto a region containing several rich clusters at various redshifts.*

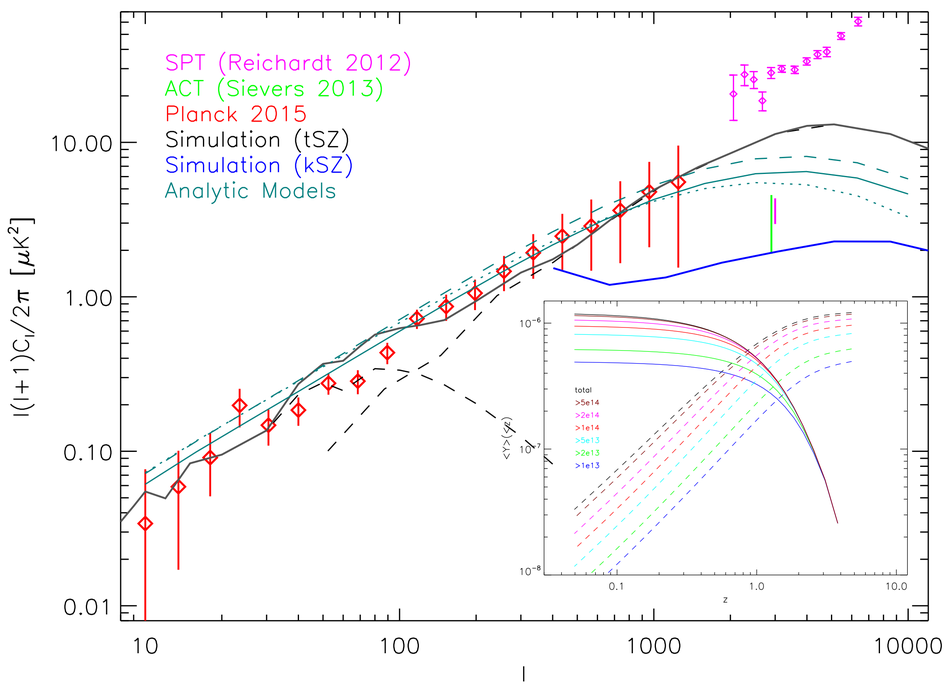


Figure 2: *The observed angular power spectrum at 150 GHz of the CMB from PLANCK (red data points, Planck Collaboration 2015) and SPT (pink data points, Reichardt et al. 2012, with only the primary signal subtracted). The black solid line shows the thermal SZ signal obtained from our simulation assuming CMB cosmology. The light blue solid line shows the analytic prediction assuming the mass function from Bocquet et al. 2015, while the dashed line uses the mass function from Tinker et al. 2008. The inlay shows the build up (solid lines) of the mean Compton Y parameter with declining redshift and the contribution of halos with different mass to it (color coded). The simulation predicts a mean Compton Y value of 1.18×10^{-6}.*

Dolag, Sunyaev & Komatsu, in prep.

Relativistic SZ for Coma

We used the Coma cluster extracted from a cosmological simulation with constrained initial condition to predict its imprint at the PLANCK frequencies. We evaluate for the first time the contribution of the relativistic correction to the observed thermal SZ signature of a cosmological simulated Coma cluster. We find that, given the temperature distribution within our simulated Coma cluster, the optimal radius to detect the distortion of the thermal SZ spectrum due to the relativistic correction is around 30 arc-minutes. Computing the thermal SZ signal neglecting the relativistic correction will cause an upward bias in y_c of up to 50% in the central region of the Coma cluster. Fitting the relativistic correction using all PLANCK frequencies allows to reconstruct the true, mass weighed temperature map of the Coma cluster.

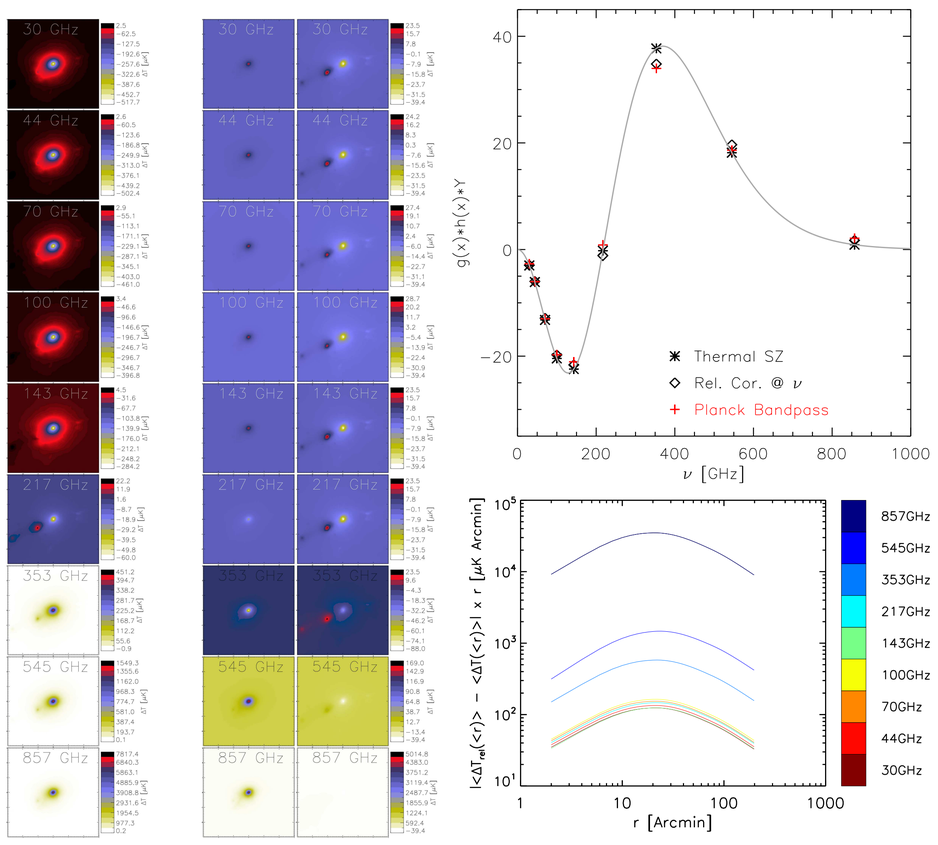


Figure 3: Left: *The predicted CMB temperature maps for the simulated Coma cluster at the three LFI and 6 HFI frequencies of PLANCK. First column: Total signal; second column: contribution due to relativistic corrections; third column: contribution due to the kinematic corrections.* Upper right: *The spectral shape of the SZ is shown without (asterisks) and with (diamonds) the relativistic corrections, and taking the PLANCK bandpass into account (crosses).* Lower right: *The radial dependent contribution of the relativistic correction.*

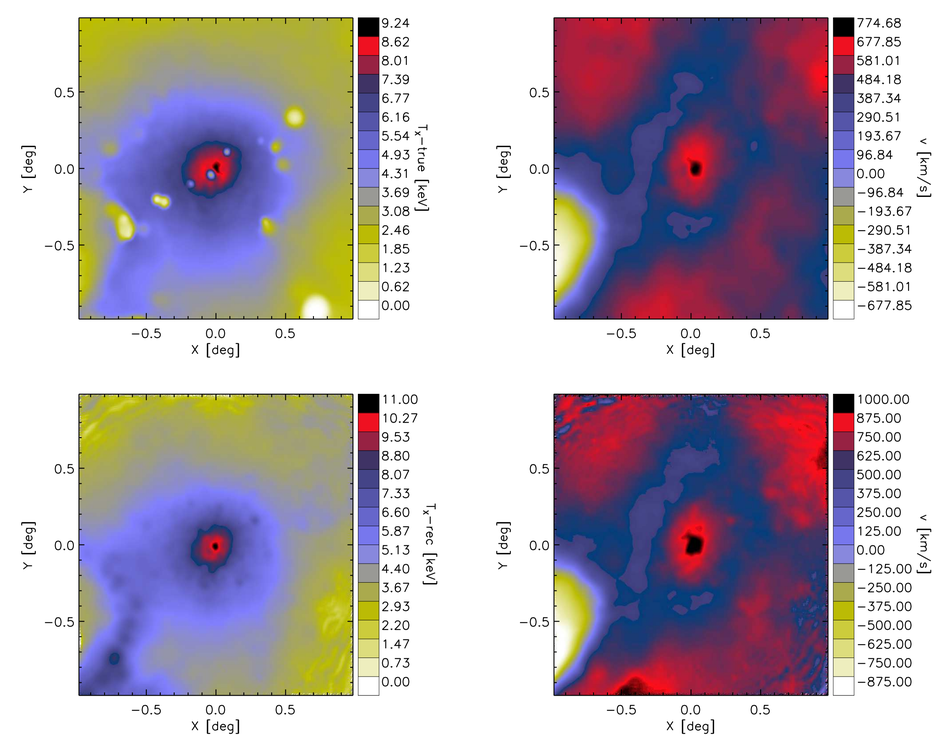


Figure 4: Top row: *The mass weighted temperature map (left) and the mass weighed velocity map (right) of one degree field of view for the simulated Coma cluster.* Bottom row: *The recovered map from fitting the full signal including the relativistic corrections and the kinetic effect over all PLANCK frequencies.*

Saro & Dolag, in prep.