A74, Dartmouth College
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A74 EXERCISES: S-Z Effect (7b)

Note: the annotation on the last figure of my notes is wrong, the cluster is not hotter or colder than the CMB at different frequencies. The break at 218 GHz is a result of the IC up-scattered photons being "stolen" from lower frequencies.

1. The intracluster medium (ICM) of the Abell 2597 Galaxy Cluster has an average electron number density of 5×10^{-3} cm^{-3} out to a radius of 200kpc according to Wulandari et al. (2019). The ICM has an electron temperature of about 10^8K.

   (a) Verify that the electron temperature is such that we are in the inverse Compton scattering regime for the CMB (that is, the CMB photons gain energy).

   (b) What is the optical depth of the ICM to Compton scattering? Approximately what percentage of photons will interact?

   (c) What is the fractional energy change per interaction, and the associated Compton y parameter for the ICM?

   (d) S-Z effect measurements are made at radio wavelengths, since that is where the CMB blackbody peaks. What is the observed temperature shift from the S-Z effect?

   (e) Considering the calculations you just did, if you measure the S-Z effect in a galaxy cluster of unknown physical extent (e.g. at an unknown redshift) and independently gain knowledge of the electron temperature and electron number density, how can you use the S-Z effect to measure the Hubble constant?