The Sunyaev-Zel'dovich effect around voids

All of us[1]

[1] *Miskatonic University*

I. INTRODUCTION

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

II. THEORETICAL MODEL

The tSZ signal caused by a particular structure at redshift z is given by

$$y(\theta) = \frac{\sigma_T}{m_e\, c^2} \int \frac{dr_\parallel}{1+z} P_e\left(\sqrt{r_\parallel^2 + r_\perp^2}\right), \qquad (1)$$

where σ_T and m_e are the Thomson scattering cross section and the electron mass, $P_e(r)$ is the electron pressure profile of the structure, $r_\parallel$ and $r_\perp \equiv \chi(z)\theta$ are the longitudinal (parallel to the line of sight) and transverse comoving distances from the structure, $\chi(z)$ is the comoving distance to redshift z and θ is the angular separation from the center of the projected structure.

The tSZ signal around voids can therefore be predicted by estimating their expected excess electron pressure profile. We do so here by connecting the void density profile, which can be estimated directly from the data, with $P_e(r)$ using the so-called "effective universe" approach. This method is spelled out in Appendix A, and has been previously used in analyses of environmental effects on halo abundances [? ? ? ?]). In short, one can associate the void underdensity $\delta(r)$ with a set of effective cosmological parameters $\Omega_X(r)$, which can then be used to estimate any quantity in the void as its background value in that effective cosmology.

The problem therefore reduces to estimating the background free electron pressure for a given set of cosmological parameters. Assuming the main contribution to the total tSZ signal comes from the hot gas in dark matter haloes, the total electron pressure at a point $\mathbf{r}$ is given

by the sum of the contributions from all haloes:

$$P_e(\mathbf{r}) = \int d\mathbf{x}^3\, dM\, n(M, \mathbf{x}) P_e(|\mathbf{x} - \mathbf{r}|, M), \qquad (2)$$

where $n(M, \mathbf{x})$ is the number density of haloes of mass M (i.e. the position-dependent halo mass function), with pressure profile $P_e(r, M)$. The background contribution to the electron pressure is therefore found by taking the ensemble average of the equation above:

$$\langle P_e \rangle = \int dM\, n(M) \frac{4\pi}{3} \int dr\, r^2\, P_e(r, M). \qquad (3)$$

To summarize, the process to estimate the void's electron pressure profile is therefore as follows:

1. Estimate the void's over-density profile $\delta(r)$.

2. At a given r, relate $\delta(r)$ to a set of effective cosmological parameters $\Omega_X(r)$.

3. The void's electron pressure at that r is then computed using Eq. 3 as the background electron pressure for the corresponding effective cosmology parameters. Note that, in this equation, both the mass function and the halo pressure profile depend on Ω_X.

III. DATA

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

IV. RESULTS

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac

habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

V. DISCUSSION

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehic-

ula.

[?] [?] [?] [?] [?]

Appendix A: The effective-universe approach to void-related quantities

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.