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THE ANGULAR POWER SPECTRUM OF DUST-OBSCURED GALAXIES AND ITS IMPACT ON SUNYAEV ZEL'DOVICH STUDIES

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RESUMEN

En este trabajo medimos el espectro angular de potencias de la población de galaxias milimétricas (SMGs) a partir de observaciones a 1.1 mm realizadas con la cámara AzTEC en el Atacama Submillimeter Telescope Experiment (ASTE) y el James Clerk Maxwell Telecope (JCMT). La muestra de campos observados nos permite comparar el espectro angular de potencias de las SMGs medido en la dirección de regiones del Universo sin sesgo y otras sobre densas. Nuestras mediciones permiten acotar el impacto que tiene la población de SMGs en mediciones del espectro de potencias de las fluctuaciones primarias y secundarias del fondo cósmico de radiación de microndas (CMB), que actualmente están siendo medidas por una nueva generación de experimentos con resoluciones espaciales del orden de minutos de arco y que operan a longitudes de onda milimétricas.

ABSTRACT

In this work we measure the angular power spectrum (APS) of the population of (sub-)millimetric galaxies (SMGs) using 1.1 mm wavelength observations obtained with the AzTEC camera on the Atacama Submillimeter Telescope Experiment (ASTE) and the James Clerk Maxwell Telescope (JCMT). The sample of survey fields allows us to compare the properties of the APS of the (sub-)mm galaxy population towards unbiased and potentially overdense regions of the Universe. Furthermore, our measurements provide a strong constraint to the impact that the SMGs have on the APS of the primary and secondary CMB anisotropies, which are being measured by the new generation of arcminute resolution SZE experiments at millimeter wavelengths.

Key Words: cosmic background radiation — cosmology: observations — submillimeter: galaxies

1. INTRODUCTION

A new generation of arcmin resolution CMB experiments with (sub-)mm wavelength detectors are currently operating (e.g. ACT, SPT, *Planck*, etc). One of their main goals is to accurately trace the APS of the CMB anisotropies at scales of a few arcminutes ($2000 \lesssim \ell \lesssim 8000$). At these angular scales the power of the primary CMB anisotropies drops exponentially, and the shape and amplitude of the CMB APS starts to be dominated by secondary anisotropies, mainly due to the thermal Sunyaev Zel'dovich effect (SZE, Sunyaev & Zeldovich 1970), a redistribution of the CMB photons energy due to their interactions with the free electrons in the hot intra-cluster-medium (ICM) of massive galaxy clusters. The amplitude of the SZE APS is strongly related to the amplitude of mass fluctuations in the Universe ($\propto \sigma_8^7$, Komatsu & Seljak 2002). To take advantage of this property, however, accurate measurements and a proper understanding of different systematic errors is required.

At $\ell \gtrsim 3000$, however, the APS of the SMG population and radio galaxies with strong millimetric emission, significantly contribute to the total APS, and dominate it at the highest multipoles. Though the brightest radio galaxies and SMGs may be identified and extracted from the arcmin resolution maps, the remaining population of fainter SMGs will still contribute to the measured APS, thereby contaminating and introducing systematic errors to any results or parameters derived from these observations.

In this work we use 1.1 mm observations taken with the 144 bolometer camera AzTEC (Wilson et al. 2008) on the 10 m ASTE ($\theta_{\rm fwhm} \approx 30''$) and the 15 m JCMT ($\theta_{\rm fwhm} \approx 18''$), to measure and compare the APS of SMGs towards unbiased blank fields and potentially over dense regions of the Universe. Our measurements also allow a more direct observational estimation of the contamination to SZE studies due to the SMGs, which is commonly predicted from theoretical and semi-analytical models constrained by shorter wavelength results (e.g. 850 μm SCUBA and 250, 350, 500 μm BLAST galaxy number counts).

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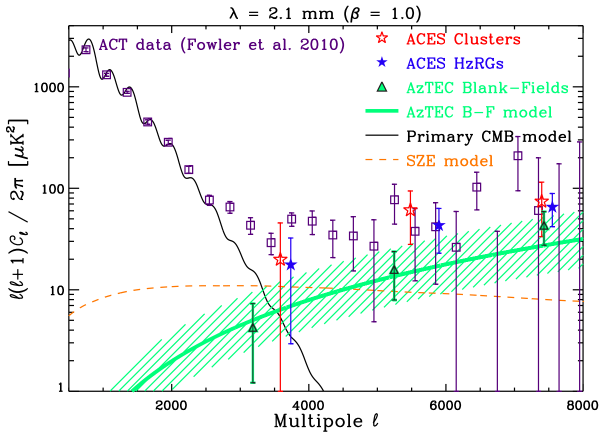

Fig. 1. Extrapolation of the 1.1 mm AzTEC power spectra to 2.1 mm assuming an emissivity index $\beta = 1$. The shaded region corresponds to the extrapolations of a 1.1 mm blank field simulation assuming $0.5 \leq \beta \leq 1.5$. The squares and the dashed curve show the ACT measurements of Fowler et al. (2010) and the SZE APS predicted by Komatsu & Seljak (2002) for $\Omega_b = 0.0441, h = 0.722$, and $\sigma_8 = 0.8005$.

2. SAMPLE AND METHOD

Our sample consists of deep ($\sigma_{\rm rms}$ ∼1.5–0.5 mJy/beam) observations of 8 blank fields that cover a total area of $A_{\rm tot} \sim 2$ sq.deg, and the AzTEC Cluster Environment Survey (ACES, $A_{\rm tot} \sim 2$ sq.deg) with observations towards 23 galaxy clusters ($0.05 \lesssim z \lesssim 1.0$) and 17 High-$z$ Radio Galaxies (HzRGs, $0.5 \lesssim z \lesssim 6.3$). The AzTEC data reduction pipeline (Scott et al. 2008) is designed to eliminate most of the extended features from the maps and optimize the detection of point-like structures (e.g. unresolved SMGs).

The size of the individual maps allows us to apply a small angle approximation, and therefore the APS can be estimated through Fourier analysis instead of a complete spherical harmonic decomposition. The effects of noise and shape of the maps are taken into account, and through simulations we find that our measurements are secure for $3500 \lesssim \ell \lesssim 10000$.

To compare against other observations and models we extrapolate our results to different wavelengths assuming that the (sub-)mm flux of SMGs scales with frequency as $F_\nu \propto \nu^{2+\beta}$.

3. RESULTS AND DISCUSSION

Figure 1 shows the averaged APS of the galaxy clusters, HzRGs, and 3 of the blank fields (COSMOS, SEP, and GOODS-s) in our sample. Our results are extrapolated to 2.1 mm, a common waveband to most of the new SZE experiments, assuming an emissivity index $\beta = 1$. Also shown are: the APS of a simulated population of SMGs randomly distributed in space and following the integrated number counts measured in the AzTEC blank fields, the ACT 2.1 mm measurements from Fowler et al. (2010), and the theoretical SZE APS predicted by Komatsu & Seljak (2002).

The averaged APS of the ACES clusters and HzRGs show an excess of power compared to the 3 blank fields ($A \sim 1.1$ sq.deg). This excess can be explained, in the case of the galaxy clusters, by gravitational lensing magnification of the background population of SMGs and possibly residual SZE signal that is not removed by the reduction process. On the other hand, HzRGs are expected to reside in potentially over dense regions of the Universe, increasing the probability of finding an excess of SMGs towards these fields (see Zeballos et al. 2011).

Given this bias, we chose to compare our blank-field APS with other wide-area surveys. The amplitude of our averaged blank field APS is a factor 1.3–4.7 lower than other observational results, e.g. ACT (2.1 and 1.4 mm, Fowler et al. 2010; Das et al. 2010), APEX (2.1 mm, Reichardt et al. 2009), SPT (2.1 mm, Hall et al. 2010), but consistent within the errors. These discrepancies could result in a reduced estimation of the SZE APS, which would therefore produce 5–20% lower predictions of σ_8. On the other hand, results from different models (e.g. Negrello et al. 2007; Sehgal et al. 2010; Lagache et al. 2004), extrapolated to 2.1 mm, overpredict the amplitude of the SMGs APS by factors of ∼3–100 compared to our measurements.

Recent optimizations of the AzTEC reduction pipeline, improvements in our procedure to estimate the APS, and the analysis of the complete AzTEC sample, will result in a more precise estimation of the SMGs APS, and may allow us to test predictions of the clustering strength of this population of galaxies.

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