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The clustering of merging star-forming haloes: dust emission as high frequency CMB foreground

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Future observations of CMB anisotropies will be able to probe high multipoles of the angular power spectrum, corresponding to a resolution of a few arcminutes. Dust emission from merging galaxies is one of the foregrounds that will affect such very small scales. We estimate the contribution to CMB angular fluctuations from objects that are bright in the sub-millimeter band due to intense star formation bursts following merging episodes. We set the free parameters using several observational tests. We show that the angular power spectrum arising from the distribution of such star-forming haloes will be one of the most significant foregrounds in the high frequency channels of forthcoming CMB experiments, such as PLANCK, ACT and SPT. The correlation term is dominant in the broad range of angular scales $200 < l < 3000$. Poisson fluctuations due to bright sub-millimeter sources are more important at higher l, but since they are generated from the brightest sources, such contribution could be strongly reduced if bright sources are excised from the sky maps. The contribution of the correlation term to the angular power spectrum depends strongly on the redshift evolution of the escape fraction of UV photons. The measurement of this signal will therefore give important information about galaxies in the early stage of their evolution.

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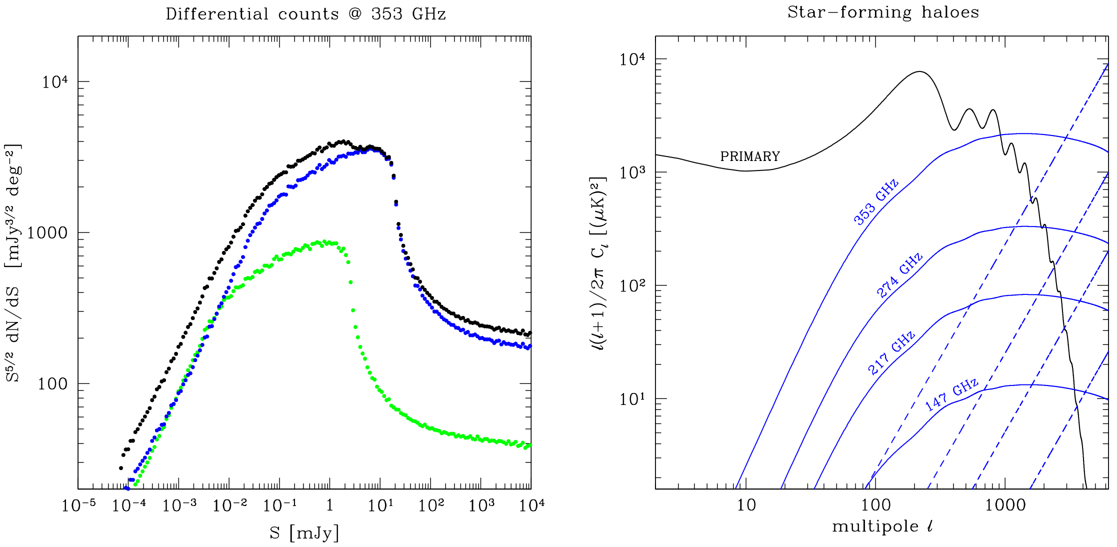

Figure 1: *Left:* the differential source counts at 353 GHz. Different colours identify different phases of star formation activity as described in the text: the green is characterized by a ∼ 300 Myr burst, while the blue one has a typical timescale of about 50 Myr. *Right:* the power spectrum of merging star-forming haloes at 353 GHz: correlation (solid) and Poisson (dashed).

1. Star formation in merging, luminosity function and dust emission

We derive the star formation rate as a function of the rate of baryonic mass accreted into new haloes. The mass of new stars created into each merging episode is proportional to the baryonic mass of the merging haloes, according to an efficiency parameter ($\eta \sim 5\%$). Only the haloes with a cooling time shorter than Hubble time are considered. We then introduce a characteristic timescale for the star formation, following the results of numerical simulation of gas-rich merging galaxies, e.g. Springel & Hernquist 2005 [1]. Three phases of star formation activity, with different characteristic timescales, are identified, but only two of them are connected with the merging activity and are therefore included in the model. Star formation rate in each merging object is related to the corresponding far-infrared (8-1000 μm) luminosity through the Kennicutt relation (Kennicutt 1998 [2]). The number density of merging objects in the universe can be derived in the context of the extended Press-Schechter formalism (Lacey & Cole 1993 [4]) and allows us to obtain the FIR luminosity function of star-forming merging objects.

2. Dust emission model

The bulk of the emission in the FIR band peaks around 100 μm and is due to low temperature dust (Lagache et al. 2005 [3]). The spectrum can be well fitted by a single-temperature graybody spectrum, $L_\nu \propto \nu^\beta B_\nu(T_{\rm dust})$, characterized by two spectral parameters: emissivity index β and dust temperature $T_{\rm dust}$. SCUBA observations both in the local and in the high-redshift universe give a range $30 < T_{\rm dust} < 50$ K for the dust temperature and $1.0 < \beta < 2.0$ for the emissivity index.

3. Observational tests and model calibration

Our model depends on several free parameters which can be calibrated using three main observational tests: Madau plot for cosmic star formation history (which allows us to test the merging model), the SCUBA source number counts (left panel of Figure 1, to choose the best values for the spectral parameters) and the intensity of the far-infrared background according to the observations of COBE/FIRAS (to calibrate the Kennicutt relation taking into account the effect of the escape fraction of UV photons). The closest result to the SCUBA source counts is obtained with a value of 30 K for the dust temperature and an emissivity index $\beta = 1.5$, in good agreement with the observations. The deficiency of sources at intermediate and low fluxes, compared with SCUBA, leads us to the conclusion that SCUBA observed objects of different nature and only 50% of them were merging galaxies. To satisfy the limits of COBE/FIRAS on the CIB intensity, (Fixsen et al. 1998 [6]), we need to reduce the luminosity of the sources introducing a correction to the Kennicutt relation based on a mass-dependent the escape fraction of UV photons, following the assumptions that more massive objects have higher amount of dust and lower escape fraction.

4. Results

We express the power spectrum as the sum of a Poisson plus a correlation term, which is due to the clustering of the sources (right panel of Figure 1): the latter dominates up to $l \sim 2000 - 4000$, the former is more important at smaller scales. However, since the Poisson power is mainly generated by the less abundant brightest sources, it will be possible to reduce it if the such sources are excised from the map. The bulk of the correlation power comes from sources in the redshift range z=2-6. The predictions are in good agreement with previous estimates, e.g. Haiman & Knox 2000 [7]. If the signal will be detected, it could give important information about properties of the sources, in particular about dust temperature and abundance.

References

[1] V. Springel & L. Hernquist, *ApJ*, **622** (L9) 2005

[2] R.C. Kennicutt Jr., *ARA&A*, **36** (189) 1998

[3] G. Lagache et al., *ARA&A*, **43** (727) 2005

[4] C. Lacey & S. Cole, *MNRAS*, **262** (627) 1993

[5] A.M. Hopkins & J.F. Beacom, *ApJ* **651** (142) 2006

[6] D.J. Fixsen et al., *ApJ* **508** (123) 1998

[7] Z. Haiman & L. Knox, *ApJ* **530** (124) 2000