The PLANCK 2015 model prediction mismatch of Sunyaev-Zeldovich cluster counts and a universal microwave background composed of redshifted radiation from 'dark' matter

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The PLANCK 2015 model predictions do not match the observed Sunyaev-Zeldovich cluster counts well. The discrepancy increasing towards lower signal-to-noise thresholds suggests that the data favor a steeper slope. The question is whether this behavior could be in better agreement with an alternative Planck microwave background mathematically composed of redshifted radiation from homogeneous 'dark' matter within a stationary universe. The SZE amplitude would appear continuously reduced to higher values of z due to an absorption constant $\kappa = 2$ $[/R_H]$. In any hot-gas cluster the modified effect should stay present due to full local CMB, while a gradual shift of the spectral profile to lower frequencies seems ruled out, though only if based on ΛCDM priors. In contrast to historical attempts, now with redshift taken into account, the hDM radiation discussed here seems to provide the only arguable alternative describing a CMB origin within the universe.

Keywords: Sunyaev Zeldovich effect, Planck cluster counts, CMB, stationary background universe

1. Introduction

A perfect Cosmic Microwave Background (CMB) is shown to be mathematically composable of redshifted radiation according to a stationary universe model (SUM)[1]. This CMB might be emitted from a macroscopically non-lensing background of homogeneous 'dark' matter (hDM). Such a feature should be falsifiable by the PLANCK 2015 observations of the Sunyaev Zeldovich effect[2] (SZE) which, however, show a partial mismatch[3] between observed and predicted cluster counts. Previously Lieu, Mittaz, & Zhang[4] pointed out a puzzling discrepancy between predicted and detected SZE profiles, reflecting how a cosmological CMB origin could be reconciled with their results. Now given the PLANCK 2015 mismatch and other peculiarities – the Supernova data are easily deduced in the SUM framework[5] on universal scales $z > 0.1$ without any need for 'dark energy' – it seems reasonable to reconsider the SZE, too.

2. Mathematical CMB Composition of universal redshifted hDM radiation

In a non-expanding stationary universe the spectral density of a gravitationally redshifted black body (BB) radiation ($z = \mathrm{e}^{Hl^*/c} - 1$) would be inclusive of absorption with constant κ

$$\rho_{\nu,\Theta} \equiv \rho_{\nu,\Theta_\mathrm{E}/(1+z)} = \frac{1}{(1+z)^{1+\kappa}}\,\rho_{\nu_\mathrm{E},\Theta_\mathrm{E}} \tag{1}$$

where as usual emitted frequency and corresponding temperature have to be replaced by

$$\nu_\mathrm{E} \equiv \nu\,(1+z)\,, \quad \Theta_\mathrm{E} \equiv \Theta\,(1+z) \tag{2}$$

(an index '$_\mathrm{E}$' means any respective quantity at place and time of its origin).

Given a frequency-dependent emissivity $\beta_{\mathrm{hDM}}(\nu_{\mathrm{E}} < 10^{12}\ \mathrm{Hz})$ at a *constant* mean temperature Θ_{hDM} — the locally emitted radiation itself is not of pure grey or black body type – the following composition leads to a perfect BB spectrum of the stationary universal microwave radiation

$$\rho^*_{\mathrm{hDM}\,\nu} \;=\; \frac{8\pi h}{c^3}\int_0^\infty \beta_{\mathrm{hDM}}(\nu_{\mathrm{E}})\,\frac{\nu_{\mathrm{E}}^3}{\mathrm{e}^{\frac{h\nu_{\mathrm{E}}}{k\Theta_{\mathrm{hDM}}}}-1}\,(1+z)^{-2-\kappa}\,\mathrm{d}z\ , \tag{3}$$

where
$$\beta_{\mathrm{hDM}}(\nu_{\mathrm{E}}) \;=\; \frac{h\nu_{\mathrm{E}}}{k\Theta_{\mathrm{hDM}}}\,\frac{1}{1-\mathrm{e}^{-\frac{h\nu_{\mathrm{E}}}{k\,\Theta_{\mathrm{hDM}}}}}\ . \tag{4}$$

It is easily verified that in case of κ=2 the integration of (3) yields exactly Planck's law

$$\rho^*_{\mathrm{hDM}\,\nu} \;=\; \frac{8\pi h}{c^3}\,\frac{\nu^3}{\mathrm{e}^{\frac{h\nu}{k\Theta_{\mathrm{hDM}}}}-1}\ . \tag{5}$$

The corresponding attenuation $1/(1+z)^2$ in the mm range would still allow measurements of quasars or radio galaxies (from e.g. Z=6 there would remain 1/49 the luminosity).

3. Split of CMB radiation statistically emitted within or beyond $z = Z$

In view of any observer at Z=0 the total Planck spectral density (5) is found by integration of (3) to include two respective parts within or beyond redshift distance z=Z, where [with substitutions $x \equiv h\nu/(k\Theta_{\mathrm{hDM}})$, $Y \equiv 8\pi(k\Theta_{\mathrm{hDM}})^3/(h^2c^3)$] the second one, given by

$$\rho^*_Z \;\equiv\; Y\frac{x^3}{\mathrm{e}^{x(1+Z)}-1} \;=\; Y\frac{x^3}{\mathrm{e}^{x}-1}\left\{1 \;-\; \frac{\mathrm{e}^{x}(\mathrm{e}^{Zx}-1)}{\mathrm{e}^{x(1+Z)}-1}\right\}\ , \tag{6}$$

seems another Planck spectrum at mathematically reduced temperature $\Theta_{\mathrm{Z}} = \Theta_{\mathrm{hDM}}/(1+Z)$ which according to (1) apparently would equal the surface brightness from any black body at redshift Z in thermal equilibrium with the CMB of constant temperature Θ_{hDM}.

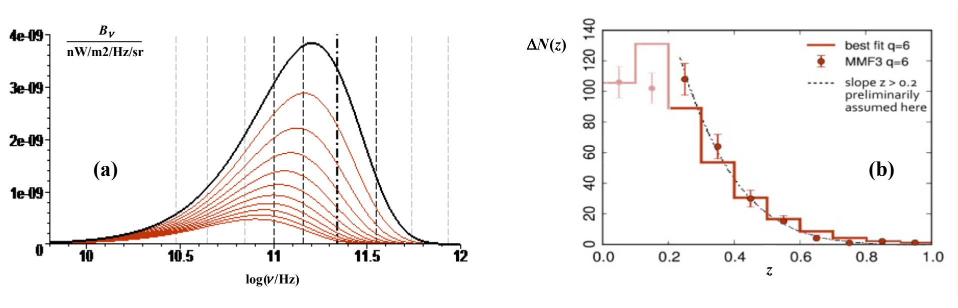

Fig. 1.(a) The SUM concept of the CMB (ρ_Z* according to 6) compared to 1.(b) the PLANCK "q=6" SZ cluster counts (modified excerpt from Fig. 4/ref. 3), where a slope mismatch appears down from the 3rd redshift bin.

The bold black line on top of Fig. 1(a) shows the total CMB spectrum as actually observed (the vertical dashed lines mark the 9 PLANCK frequencies), while thin red solid lines show top down respective parts of the universal hDM radiation coming from behind $Z = 0.1, 0.2, \ldots 1.0$ statistically. These parts $\rho_Z{}^*$ decrease with distance according to relation (6). The other way round, by far most of the BB radiation reaching telescopes would have been emitted within $Z < 1$. – The curved dashed black line of Fig. 1(b) is added for illustration of the count mismatch, unexpected in high precision ΛCDM cosmology.

On the one hand, according to the SUM concept, there necessarily exists a universal radiation equilibrium. On the other hand – in respect of (1) and in contrast to local black bodies – it seemed impossible to keep a redshifted Planck spectrum of constant temperature $\Theta_{\rm hDM}$ within a stationary universe so far. Now, however, to observe a *universal* BB background in equilibrium with all local counterparts, there would be also non-thermal components, emitted in accordance with (4). Comparing the local radiance

$$\mathrm{d}B^{*\,\mathrm{local}}_{\mathrm{hDM}} \;=\; 4B^{*\,\mathrm{SB}}_{\mathrm{hDM}}\,\frac{\mathrm{d}r^*}{R_H} \;=\; \mathrm{d}A^{*\,\mathrm{local}}_{\mathrm{hDM}} \tag{7}$$

in a shell of 'comoving' universal thickness dr^*, this is found equal to the local attenuation d$A^*{}_{\rm hDM}{}^{\rm local}$ where, according to Stefan-Boltzmann's law, $B^*{}_{\rm hDM}{}^{\rm SB}$ is the radiance of hDM black-body radiation. The attenuation is due to local absorption *plus* local redshift. Thus, an energetic equilibrium results for emission and attenuation in the same shell, allowing for statistical energy recycling (including hDM infall to active galactic nuclei).

4. hDM anisotropies, fluctuations, inhomogeneities

Universal microwave radiation originates here from 'dark' matter (various constituents), whose vast isothermal main part is distributed homogeneously (hDM instead of the assumed 'dark energy'), while a smaller inhomogeneous part, iDM, seems gravitationally condensed to halos (usual 'dark matter', whether or not bound to galaxies or clusters). Old arguments against CMB emission from individual sources become meaningless now.

In view of straight SUM, though, there is no horizon concerning the infinite universe as a whole. How other observable features include some fiducial lengths to explain the CMB anisotropies, will need detailed investigations. In any case this chance also implies acoustic hDM oscillations which again are understood to arise from gravitational attraction and radiation pressure. Though such acoustic oscillations are easily conceivable within voids, there cannot be an unnecessary consistent phase coherence of fluctuations all over the universe. If it were not for several peculiarities like in particular the low-multipole alignments[6] ('axis of evil'), a hemispherical power asymmetry or the strange 'cold spot', it might seem an unreasonable attempt to question the assumed big-bang origin of the CMB and thereby the exceptionally successful inflationary ΛCDM cosmology. However, some even more fundamental problems may also not be forgotten like the matter-antimatter asymmetry or the assumed big bang origin from a vacuum fluctuation background which is not represented by any line element of Einstein's equations describing a relativistic counterpart so far (except for the stationary line element of SUM).

Any structure at a universal ('comoving') distance of about 70 times its diameter is observed at about an acoustic scale angle of 0.8° on the sky, as might roughly apply to e.g. large voids (order 60 Mpc) at Hubble distance $R_H \equiv c/H$, or particularly to cluster distances (order 6 Mpc) in the transition zone to universal homogeneity at $Z \approx 0.1$ (order 400 Mpc) or also to galaxy halos (order 80 kpc) at cluster distances. The whole microwave background may have to be taken into a new consideration without ΛCDM priors.

5. The thermal Sunyaev Zeldovich effect in the SUM framework

In each cluster the full local CMB radiation is subject to inverse Compton scattering. According to (1), (6) all particular clusters may be regarded as local 'sources' of the SZE signal at respective redshift *Z*. With respect to Section 3 the SUM counterpart to the well-known SZE should appear increasingly reduced at high redshifts according to

$$\Delta I_{\mathrm{SUM}}^{\mathrm{SZ}} = I_0 \, y \, \frac{g(x_{\mathrm{E}})}{(1+Z)^3} \; , \tag{8}$$

where as usual y is correlated to cluster masses (often unknown), and $g(x_{\mathrm{E}})$ arises from

$$g(x) \equiv \varepsilon(x) \cdot f(x) \equiv \frac{x^4 \mathrm{e}^x}{\left(\mathrm{e}^x - 1\right)^2} \cdot \left[x \coth\!\left(\frac{x}{2}\right) - 4 \right] \tag{9}$$

after replacing x by $x_{\mathrm{E}} \equiv h\nu_{\mathrm{E}}/(k\Theta_{\mathrm{hDM}}) \equiv h\nu\,(1+z)/(k\Theta_{\mathrm{hDM}})$. Regarding the PLANCK results as well as previous measurements[7], however, frequency shifts according to (8) seem ruled out at first sight. Modifications are exemplarily shown in Fig.s 2 for $y = 10^{-4}$.

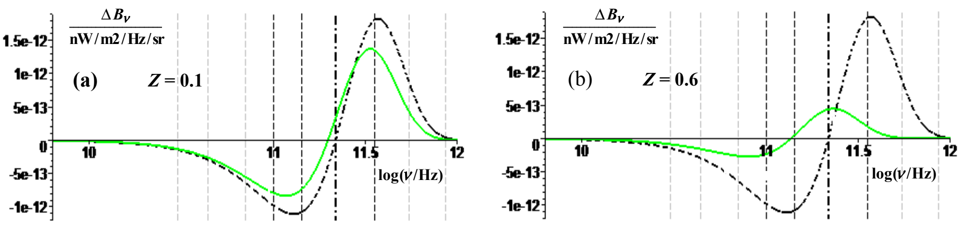

Fig. 2. The curved dashed black lines in figures (a), (b) show the SZE as expected in ΛCDM cosmology. The curved green lines show ΔB_ν with spectral function $g(x_{\mathrm{E}}) = x_{\mathrm{E}}^4 \mathrm{e}^{x_{\mathrm{E}}}[x_{\mathrm{E}} \coth(x_{\mathrm{E}}/2) - 4]/(\mathrm{e}^{x_{\mathrm{E}}} - 1)^2$ shifted according to $\Theta_{\mathrm{Z}} = \Theta_{\mathrm{hDM}}/(1+Z)$ of radiation from behind e.g. $Z = 0.1$, 0.6 here (without any additional inhomogeneities).

Like in ΛCDM cosmology a temperature Θ_Z of radiation coming from behind Z is observed at $\Theta_{\mathrm{CMB}\text{-}Z}/(1+Z)$; the difference is, that here $\Theta_{\mathrm{CMB}\text{-}Z} = \Theta_{\mathrm{CMB}} = \mathit{constant} = \Theta_{\mathrm{hDM}}$. The total hDM radiation of non lensing sources is constituting the SUM Planck spectrum statistically. Hence the green solid lines of Fig. 2 should be considered. In contrast to the ΛCDM cosmology, however, additional 'primordial' microwave inhomogeneities will also arise between cluster and observer. – According to (3), (4), the SUM contribution of one spherical shell to the CMB blackbody spectrum is

$$\Delta\rho^{*}_{\mathrm{HDM}\,\nu} = Y \int_{Z}^{Z+\Delta Z} \varepsilon(x_{\mathrm{E}})(1+z)^{-2-\kappa}\,\mathrm{d}z \approx Y \frac{x^4\,\mathrm{e}^{x_{\mathrm{E}}}}{(\mathrm{e}^{x_{\mathrm{E}}}-1)^2}\Delta Z \,, \qquad (10)$$

what thus may imply isothermal fluctuations of order 10^{-4} within approximately 100 kpc. It is remarkable that for $Z = 0$ the integrand of (3) or (10), which leads to the observed CMB Planck spectrum, equals the well-known SZ-factor $\varepsilon(x)$ of $g(x)$ [s. (9)] exactly.

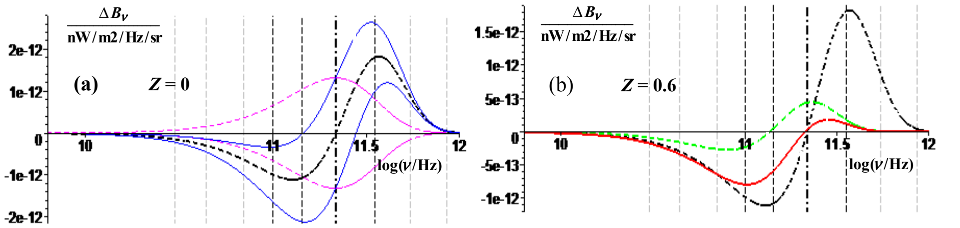

Fig. 3 Isothermal SUM fluctuations of order $y \approx 10^{-4}$ are plotted red in 3.(a), while the thin curved blue lines show changes of the local SZE. – Fig. 3.(b) shows as bold red line a resulting SZ signal ($X_{\mathrm{back}} \approx -5 \cdot 10^{-5}$) where the frequency shift, green, seems largely compensated (lower intensities might be interpreted as lower y's).

Therefore a more complete spectral distortion of the microwave background according to SUM may be written

$$\frac{\Delta I_{\mathrm{SUM}}}{I_0} = y\frac{g(x_{\mathrm{E}})}{(1+Z)^3} + X_{\mathrm{back}}\,\varepsilon(x_{\mathrm{E}}) + X_{\mathrm{fore}}\,\varepsilon(x_{\mathrm{fore}}) \quad , \qquad (11)$$

since given a CMB origin within the universe one has to discern between inhomogeneities in the 'back'-ground and those in the 'fore'-ground of any SZ-clusters. Regarding Fig.s 3, it may be remarked that the redshift Z = 0.6 exemplarily assumed in Fig.s 3.(b), 2.(b) corresponds only coincidentally to that of SPT-CL J2344–4243 (Phoenix Cluster, the most X-ray luminous cluster known in the universe, whose SZE has been detected with a signal-to-noise ratio of $\xi = 27.44$ in the SPT Survey[8], while a SNR-value of $\xi = 6.73$ is given in the Planck data psz1v2_1). It has to be noted that any resolvable contribution of the Cosmic Infrared Background (CIB) observed e.g. from this Phoenix Cluster, may not be resolvable if observed from the solar system. No doubt that there is a plenty of corresponding distant point sources; as well as – according to SUM – any fundamental exact distinction between the CMB and CIB can hardly make a clear sense[1] particularly in the overlapping frequency range, where the CIB contributions do not vanish at all.

6. Discussion and conclusion

Originally, the aim of SZ cluster surveys has been to detect previously unknown galaxy clusters via the thermal SZ effect at frequencies mostly below 217 GHz. Now the

PLANCK data encompass nine frequencies (s. Fig.s). At those above 353 GHz, however, the radiation is increasingly dominated by galactic and extragalactic emission as stated in Planck-XXIII[9]. In the 220 GHz SPT-SZ maps the relative noise levels were found too high to significantly improve cluster detection[8].

In spite of its SZ frequency shift (increasing with redshift) a straight SUM cluster search should work up to Z≈0.5, Z≈1, Z≈2, Z≈3, Z≈5 using frequency bands up to 143 GHz, 100 GHz, 70 GHz, 44 GHz, or 30 GHz respectively. Therefore, even without taking any additional inhomogeneities into account, the SUM-SZE would stay detectable at e.g. Z = 1.9 (XLSSU J0217–0345) particularly using the same 30 GHz band[10]. Not all existing clusters might show the expected SZE, though. And particularly in view of the PLANCK 15 cluster count mismatch it appears doubtful whether the data can be fully explained without ascribing more *ad-hoc* features to the 'big bang' universe. So far, clusters showing a SZ signal as assumed in ΛCDM cosmology were found best. Anyway, however, the risk of significant selection bias effects has to be taken into consideration[11].

In view of SUM both forms of 'dark' matter get rid of their mysterious lack of non-gravitational interaction. It may be worth to check – or finally exclude – an actually unexpected CMB origin within the universe. An extensive SZE exploration without ΛCDM priors seems appropriate in particular with the plenty of PLANCK data available now.

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