Echoes of the big bang … or noise?

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The report

A 2 February 2004 press release, from the Royal Astronomical Society (RAS) was headlined as 'corrupted echose from the big bang?' on their own website[1] and 'Are galaxy clusters corrupting Big Bang echoes?' on the *Spaceflight Now*[2] website. All the excitement was in response to a new analysis of data from NASA's Wilkinson Microwave Anisotropy Probe (WMAP). A team at the University of Durham, led by Professor Tom Shanks, have reported that the variability in cosmic microwave background radiation (CMB) data is significantly distorted by clouds of gas through which it has travelled.

These headlines are amazing, as the WMAP data had been previously heralded as being the most precise measure of the early echoes of the big bang. They were called echoes because it was believed they were the result of the acoustic waves generated at the stage, after the big bang, where radiation separated from matter. The small-density fluctuations in the matter/radiation density at that time, which resulted in the echoes, is claimed to be the seed for the formation of galaxies and clusters later in the development of the universe.

This new information may undo all that has been claimed by the proponents of the big bang. The high-precision resolution of many parameters of the standard hot big bang (BB) inflationary model of the origin of the universe may be all wrong. The RAS press release goes on to say:

> 'But if correct, they suggest that the rumours that we are living in a "New Era of Precision Cosmology" may prove to be premature! "*Our results may ultimately undermine the belief that the Universe is dominated by an elusive cold dark matter particle and the even more enigmatic dark energy*", said Professor Shanks' [emphasis added].

It could even lead to the rejection of cold dark matter and dark energy, which incidentally are locally unknown physical concepts but are necessary to make the BB model work.

The evidence

What have they actually discovered? The press release is quite clear:

> 'The team has found that nearby galaxy clusters appear to lie in regions of sky where the microwave temperature is lower than average. This behaviour could be accounted for if the hot gas in the galaxy clusters has interacted with the Big Bang photons as they passed by and corrupted the information contained in this echo of the primordial fireball. Russian physicists R.A. Sunyaev and Ya. B. Zeldovich predicted such an effect in the early 1970s, shortly after the discovery of the cosmic microwave background radiation.'

This Sunyaev–Zeldovich effect[3] has previously been seen in the cases of detailed observations of the microwave background, in the vicinity of a few rich galaxy clusters, and the WMAP team themselves have reported seeing the effect in their own data, close to cluster centres.

Now the Durham team has found evidence that hot gas in the clusters may influence the microwave background maps out to a radius of nearly one degree from the galaxy cluster centres, a much larger area than previously detected. This suggests that the positions of 'clusters of clusters' or 'superclusters' may also coincide with cooler spots in the pattern of microwave background fluctuations.

'The photons in the microwave background radiation are scattered by electrons in nearby clusters', said Professor Shanks. 'This causes important changes to the radiation by the time it reaches us.'

The explanation

So it seems the Sunyaev–Zeldovich (SZ) effect is far more of a problem than first expected. The effect is an inverse Compton-scattering of the microwave photons from free electrons in the hot gas. The team went on to say:

> 'The WMAP team has already reported that their measurements of the Big Bang's microwave echo may have been compromised by the process of galaxy formation at an intermediate stage in the Universe's history. They presented evidence that gas heated by first-born stars,

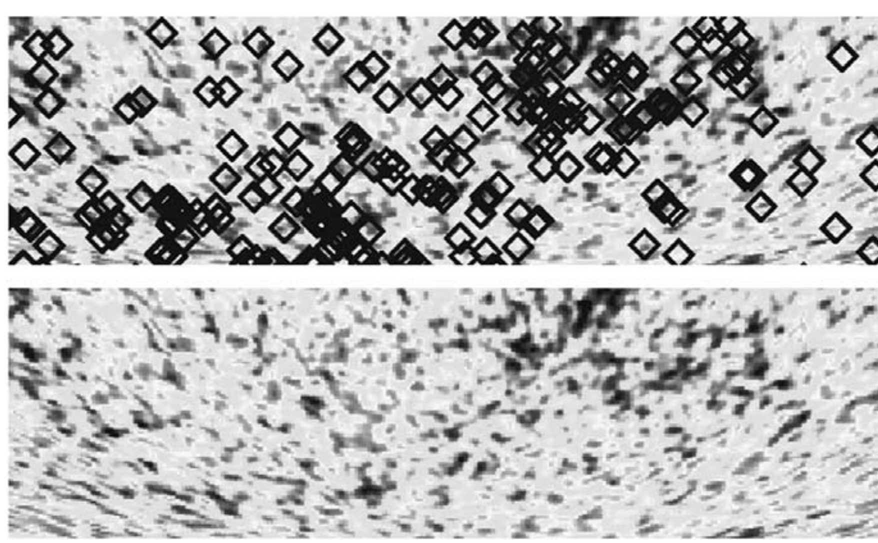

Figure 1. *The upper panel shows part of the WMAP temperature map with diamonds representing the position of nearby galaxy clusters. The galaxy clusters and superclusters tend to lie in cooler temperature regions (see the colour image in reference 10). The lower panel shows the same area without the cluster positions for reference. Reproduced from ref. 10.*

galaxies and quasars may have also corrupted the microwave signal when the Universe was 10 or 20 times smaller than at the present day. Thus both the WMAP and Durham results suggest that the microwave echo of the Big Bang may have had to *come through many more obstacles on its journey to the Earth than had previously been thought*, with consequent possible distortion of the primordial signal' [emphasis added].

The Durham team has submitted a paper on their findings to the Monthly Notices of the Royal Astronomical Society (MNRAS), in which they report that they have found temperature decrements (in the CMB temperature) that are associated with galaxy clusters and groups. The paper reports:

> 'We interpret this as evidence for the thermal Sunyaev–Zeldovich (SZ) effect from the clusters. Most interestingly, the signal may extend to ≈1 deg … around both groups and clusters and we suggest that this may be due to hot "supercluster" gas.'[4]

Theorists had previously overlooked the SZ effect, on the scale of clusters and superclusters. Model-dependent predictions for contamination of the CMB data due to the SZ effect suggested that the contamination would be small. The new WMAP data was the first real opportunity to make empirical checks of the level of contamination by direct cross-correlation of the high resolution 94GHz CMB radiation with galaxy cluster data.

The Durham team specifically investigated whether low redshift clusters could have filtered the WMAP temperature spectrum by searching for SZ inverse Compton-scattering of microwave background photons by hot gas in clusters.

The effect is clearly seen in the maps published with the RAS press release (fig. 1). The top image shows the location of galaxies and clusters (diamonds), overlaid on the CMB temperature map. The galaxy clusters tend to be concentrated in the cooler regions. For comparison, the bottom image is the same temperature profile map without the galaxy locations.

These results were obtained for low redshift ($z < 0.2$) clusters. If it is also found that the effect applies to more distant clusters and groups, then the contamination may be significantly greater, as discussed below.

Other supporting data

Another recent result[5] from WMAP data is the detection of polarization at large scales, which, it is suggested, could only have been derived from an epoch of re-ionization, at a redshift of $10 < z < 20$.

According to the theory, during the first few hundred thousand years after the big bang, the cosmic gas in the expanding universe consisted of bare protons (ionized hydrogen), electrons and helium atoms. There was a lot of radiation being generated, but it couldn't travel far, because the universe was essentially opaque. About 380,000 years after the big bang, due to the cooling of the universe to about 3,700 K, neutral hydrogen atoms could form, and radiation left over from the initial ionized state could then travel freely through space. This left-over radiation would have a redshift of $z \sim 1{,}000$ and thus appears in the microwave spectrum today (this is the source of the CMB). Some time later the first stars began to form and the radiation from these stars began to slowly re-ionize most of the hydrogen atoms in the intergalactic medium. Eventually all the hydrogen atoms in the intergalactic medium became re-ionized. Light from this 're-ionization epoch' should have redshifts between $z = 20$ and $z = 10$.[6] Looking out into space, we are effectively looking back in time, thus the re-ionization region would be in the foreground to the CMB. (I.e. according to the theory, we are looking back in time at radiation—now redshifted to the microwave spectrum—that was generated only 380,000 years after the big bang and which subsequently was polarized during the period of the first stars.)

The re-ionization effect introduces a significant (30%) reduction of the acoustic peak heights in the CMB power spectrum, due to Thomson scattering. These results confirm that low redshift galaxies will seriously affect the CMB anisotropies, because the intracluster medium is highly ionized. It also follows that the temperature spectrum must be affected by cosmic foregrounds such as the re-ionized intergalactic medium at $10 < z < 20$. The resulting contamination of the CMB data may be as much as 10 times that reported above.

The trouble for the big bang

This is very damaging evidence for the big-bangers. In recent years the claims have been made that we are near the end of solving all the outstanding issues with the big bang model, especially since the precise measurement of the 70 mK ripples in the 2.73 K microwave background. If this report proves to be true, the big bang is in big trouble. Many modern large-scale experiments are being built based on the validity of the CMB data, including the one-billion-US-dollar square kilometre array (SKA), which intends to further improve the observation of the radio and microwave radiation that is believed to emanate from the earliest time in universal history.

Moreover, it is very interesting because Hoyle, Burbidge and Narlikar[7] (HBN), in their quasi-Steady State model, expected fluctuations of the order of 30 mK in the spatial anisotropy of the CMB. Their theory says the bulk of optical radiation in the universe is being thermalized through the agency of carbon whiskers that absorb and re-emit at microwave frequencies. They are not uniformly distributed but lumpy on the scale of clusters of galaxies. According to HBN, this is consistent with the COBE satellite (and now WMAP) data, which examined the sky on a spatial angular scale, such that one beam width[8] contains a rich galaxy cluster and the other doesn't. This is a line-of-sight effect. Wherever you look in the sky and see a cluster or supercluster, the CMB will show temperature variations on that angular scale. HBN predicted the spatial scale size would be found to be the same as the size of clusters of galaxies and superclusters. So it is a prediction of the quasi-Steady State model.

Whatever the cause of the blotches in the temperature CMB maps, it seems that the big-bangers will not be able to continue claiming the precision that they have recently, after WMAP. There have been rumours that cosmologists now all agree[9] that our origin was in a hot big bang inflationary scenario. But from this new data, it seems that the big bang paradigm is in trouble again. The blotches in the temperature CMB maps may not even relate to deep space; at a minimum, the maps may be severely compromised by noise.

References

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