For review by Alan

http://www.geocentrismdebunked.org/cmb-misalignments-a-problem-for-geocentrist/

Yes, the CMB Misalignments Are a Problem for the New Geocentrists

Posted on February 14, 2015 by David Palm

by Dr. Alec MacAndrew and David Palm (02/14/2015)

The new geocentrists have been making quite a number of extravagant claims concerning the cosmic microwave background (CMB) and geocentrism. Specifically they claim that certain anomalous alignments in the CMB "point like an arrow . . . directly to the Earth", "point directly to the Earth as the center", "show that the whole Universe is centered on the Earth", etc. (see more of these claims here.) They hold this because certain features of the CMB have been said to align with the ecliptic and the equinoxes.

www.hrzone.com

Now verbiage like "point like an arrow" and "directly at the Earth" and "exact center" would naturally lead one to believe that these alignments are precise. Indeed, given that the new geocentrists argue that God created these alignments specifically to highlight the central position of the Earth, you'd expect for them to be exact.

But they're not.

In his article "The CMB and Geocentrism", *physicist Dr. Alec MacAndrew demonstrated that, to the contrary, these alignments are only approximate*.

…Expects no exp error??

In fact, they can be quite a ways off – *the CMB vectors and the ecliptic are misaligned by as much as 16 degrees, from the equinox they are misaligned by as much as 23.1 degrees, and they are misaligned between themselves by as much as 28.5 degrees.*

Straw man alert…. CMB vectors are not the topic…. Multipoles with solar system directions is the issue …

It is true that any apparent alignments are interesting to physicists if they are expecting complete randomness. But the inexactness of the alignments certainly does not create anything like a sound foundation upon which to build the extravagant claims of the geocentrists.

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In the same article, Dr. MacAndrew also pointed out that the CMB vectors provide *directional* but no *positional* information.

True in the Copernican model but not in the ALFA model…which refuted the Cosmo principle

He has now buttressed this fact with a new article, "The Derivation and Meaning of the CMB Anisotropy Vectors", which lays out the mathematics behind this fact. He also documents that this fact is stated even in the scientific articles cited by the new geocentrists. As such, to be intellectually honest, the geocentrists are going to have to abandon their claims about the CMB vectors pointing to the Earth or indicating the location of anything, including the Earth.

Now, without actually admitting that Dr. MacAndrew is right, but probably sensing that they face a serious problem, the new geocentrists have started to do damage control. In this article we'll first consider an analogy that will help us understand how these vectors convey directional but not positional information. Then we'll individually debunk all of these attempts to downplay the CMB misalignments and their implications for geocentric claims.

Cite quotes from MS re 'axis of evil'…

Evil is a moral, not scientific, judgment, made by politicians (Reagan) against the communist ideology.

MS using the same characterization to associate a scientific fact with an unacceptable belief system.

An Analogy – Direction But Not Position:

Analogies have limitations, of course, but here is one that should help the reader understand how the CMB vectors carry directional but not positional information.

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Imagine you're on a tiny rock somewhere in the middle of a vast ocean with an ocean current flowing round the rock and the wind blowing and gravity pulling you down. Can you define a vector that characterises the wind direction? Sure you can –its direction is, well, the direction to which the wind is blowing. That is analogous to one of the CMB vectors. Similarly, you can define a vector that characterises the direction of the ocean current – that is analogous to another of the CMB vectors. Can you tell which way gravity is pulling – yep, there's a third. So you have three vectors, all with origins on your little rock. And none of that information gives you a clue as to where you are in the wide ocean. Because the vectors define only direction and carry no positional information, they don't define a position. *The CMB vectors are like that – they are unit vectors that define a direction from the point of observation but they give no information about position or location.*

ALFA establishes Earth as the point of rest…. The only abs ref frame… motion must be measured rel to Earth to have valid laws of dynamics..

And the fact that the intersection of the vectors represents a point right at your location is simply true by definition, because you are at the point of observation.
False! the CMB dipole could have been between any 2 points in the sky. That the cold and hot spot are about 180 degrees apart when

measured from earth is the anomaly…the angle could have been from 0 to 180 degrees…

That you are in the "exact center" or the point of intersection of these vectors tells you nothing about your location relative to anything else. *And that centrality has no significance, because directional vectors like these will always have their origin at the point of measurement – that is how they are defined*.

The multipole analysis is wrt Earth..if there were no symmetry or centrality with earth, , then the MP coefficients would reflect that lack of symmetry around the earth.

Look for Mpole model of off-center symmetry.

Give the CMB analysts enough time, and they will bury the BB, LTB and LCDM models themselves.

The CMB dipole and the 4-and 8-pole seem aligned with the Earth.

I found a paper that tries to move the observer away from the Earth and keep the 3 multipole values the same as measured. IOW, if we are at the center of cosmic symmetry, how far can we move off-center and still measure the same multipoles? How much wiggle is in the apparent centricity of Earth?

Looky what they found….

CMB anisotropies seen by an off-center observer in a spherically symmetric inhomogeneous universe

http://arxiv.org/pdf/astro-ph/0607334.pdf

..we investigate whether such an off-center location can explain the observed alignment of the lowest multipoles of the CMB map. We find that the observer has to be located within a radius of ∼ 15 Mpc from the center [RB: that's about 10^{-3} of the alleged size of the MS universe] for the induced dipole to be less than that observed by the COBE satellite. But for such small displacements from the center, the induced quadru- and octopoles turn out to be insufficiently large to explain the alignment. [uh-oh]

….. ***We wish to examine how being situated away from the center of the LTB coordinate system affects the CMB temperature measured by the observer. Since space-time is no longer spherically symmetric around such an observer, we expect him to measure additional anisotropies in the temperature to those measured by an observer at the center.***

….. ***The observed dipole in the CMB is of the order $|a^{10}| \sim 10^{-3}$. This will put a natural constraint on how far away from the origin the observer can be located, since a farther off-center position usually means a larger dipole.***

In our previous work [1], we assumed that the observer was positioned at the center of the bubble, and found a model that gave a good agreement with the Hubble diagram of observed SNIa and the position of the first CMB peak. [Type1a Super Nova also centered on Earth…. Didn't know that]

….. The main purpose of this paper has been to determine the maximum displacement of the observer from the origin of the underdensity, for which the induced CMB dipole remains in agreement with the results observed by COBE [2]. Of course, one could in principle introduce an additional peculiar velocity towards the center of the underdensity to compensate for a too large induced dipole, but such a coincidence would be very difficult to justify. Therefore, we must require the induced a^{10} to be of order 10^{-3} or less, which from the plots in Figs. 6 and 7 can be translated to d_{obs} ~15 Mpc . (30) where d is the physical distance. When compared to the size of the underdensity, ….. this means that if we are placed at a random position inside the bubble, there is roughly a chance of 1 to 10^6 [RB: one in a million] that we end up inside the region allowed by Eq. (30). This is a rather strong violation of the Copernican principle, which states that we are not situated at a special place in the universe. On the other hand, a 10^{-6} probability is still much better than the infinitely improbable case of the observer being exactly at the center of the underdensity. Note that the size of the underdensity is dictated by the fit to the CMB and SNIa data. We have not been able to find smaller bubbles that fit these data as well as the models considered here
…..
From Figs. 6 and 7 we see that the induced multipoles become larger the farther away from the origin the observer is located, as we would expect. Thus, the largest possible quadru- and octopoles with a dipole compatible with COBE measurements are those for an observer about 15 Mpc from the origin. However, at this relatively small distance, the values for these are of

the order 10^{-7} for the quadrupole, and 10^{-9} for the octopole. It is ***therefore clear that the induced quadru- and octopole cannot explain the observed alignment of the low-l multipoles in the CMB,*** *since their contributions are negligible compared to the observed anisotropies (which are of order 10^{-5}). Furthermore, any off-center placement must necessarily result in axial symmetric contributions to the CMB spectrum. Even if such contributions were of the correct order, Raki´c et al. [16] show that they are very unlikely to explain the alignment.*

….. Eqs. (37)-(39) imply that it is impossible to obtain sufficiently large values for the quadru- and octopole as long as the dipole is within the limits set by the COBE data.

…We have seen that when the dipole is constrained by data, the quadru- and octopoles due to the off-center placement are considerably weaker than those observed in the CMB.

….A non-vanishing peculiar velocity can reduce the dipole to any desired value as long as the velocity is chosen large enough. However, multipoles due to such motion will have a hierarchical scaling similar to that which we showed in the Newtonian case. Thus, even if we manage to obtain values for the dipole and quadrupole of the correct order, the octopole would still be too weak. From this we can conclude that even when combined with other effects, the off-center placement cannot provide sufficient power to both the quadru- and octopole.

…. In summary, LTB models ….. are not ruled out on the basis of these results, but ***they do require a violation of the Copernican principle, since the observer would have to be located at a very special place.*** *The volume within which the observer can be located is severely constrained by the size of the dipole induced by an off-center placement of the observer. As a consequence of this, the quadru- and octopole turn out to have insufficient power to explain the observed alignment. …..*

[Amen]

Note they never state that the center of the CMB multipolar alignment – that very special place that violates The Principle - is the Earth (or close to it). That's infinitely improbable.

(For a detailed, technical demonstration of these facts please see "The Derivation and Meaning of the CMB Anisotropy Vectors".)

Now, with that clarification in hand, let's look at the four ways that geocentrists have tried to wiggle out of the significant *misalignment* of the CMB vectors.

Geocentric claim #1: The misalignments might not even be real.

Claim denied…the proof of reality is that the MS researchers can't believe the data themselves….no cover-up or stonep-walling…just shock.

Reality: The misalignments are very real, being documented in the very literature cited by the geocentrists.

www.do-the-math.us/

Dr. MacAndrew calculated the angles between the various vectors and the equinoxes and ecliptic plane using the data from the most recent and accurate measurements of the CMB. In at least one place Sungenis casually dismisses these misalignments as merely Dr. MacAndrew's "ipse dixit calculations", implying that they may not exist at all. This is unacceptable. Dr. MacAndrew told the geocentrists where he got the most recent and accurate CMB data. And since we're talking about mathematics here then either Dr. MacAndrew got the calculations right or he got them wrong. In "The CMB Alignment Challenge" we challenge the geocentrists to do the

math, show their work, and then tell us either that Dr. MacAndrew was right or Dr. MacAndrew was wrong about these misalignments.
Will they answer the challenge?

Geocentric claim #2: The misalignments don't matter because they still place the Earth right at the origin of the vectors.

> **Denied: Who would say that there is no experimental error… the galaxy foreground contribution has been filtered out…. Itself introducing errors.**

Reality: The point of observation will be at the center of these vectors *by definition*.
Sungenis has tried to argue that the fact that the vectors intersect at a single point somehow establishes the Earth at some physical central point of the universe:

In order to have an exact position (or what we would call the "exact center" in the universe), we need an X axis, a Y axis and a Z axis, since that will give us three dimensions in Euclidean space. The CMB dipole and quadrupole give us the X and Y axis, but not the Z axis. Hence, the X and Y axis of the CMB provide a direction, but only an approximate position. That is why we have continually said that the CMB puts Earth "at or near the center of the universe." For the Z axis we depend on other information, such as quasars and galaxy alignment that the CMB cannot provide ("Debunking Palm and MacAndrew on the CMB Evidence", p. 8).

But as we've seen in the ocean analogy above, these vectors will *by definition* intersect at the point of observation and that tells us nothing about the location of that intersection with respect to anything else in the universe. In other words, it is Sungenis's ignorance at work here – this does not provide any evidence at all of the Earth's alleged physical centrality.
Geocentric claim #3: The misalignments are so small that they don't matter.

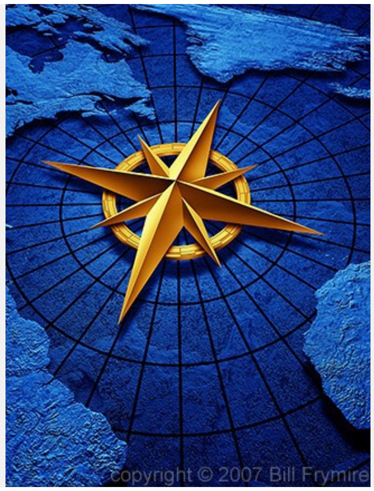
> **Denied – never claimed. Red herring alert…**

Why are we discussing the small deviations from perfect alignment when the elephant in the living room is that the alignments are so statistically unlikely that they inspire fear in the analysts…the axis of evil!

ALFA theory refutes GR and establishes the earth aas the abs ref frame…   The CMb data supports that refutation…

Reality: The misalignments are very significant and even the geocentric analogies show that.
Sungenis also argues that these misalignments don't matter because they get you "close" enough. He uses this North Pole analogy in support of the claim:

Let's say someone asked you, "Which direction must I travel to get to the North Pole?" To help him, you pull out your compass and wait for the dial to settle. You point him to the direction that the dial is pointing and declare, "That way is North Pole." But is this exactly true? No, since the magnetic field to which the compass points is a few degrees away from the precise North Pole axis. But, of course, your direction will get him very close to the North Pole . . . (*ibid*., p. 8).
Now of course, the analogy is fundamentally and fatally flawed because these vectors don't "point" at or distinguish any planets or stars or galaxies and you cannot navigate by them to any such features in the Universe. So at its heart this analogy is based on Sungenis's flawed understanding concerning the nature of the CMB vectors and the information they convey.



http://www.billfrymire.com/gallery/compass-world-map-Northpole-guide-direction.jpg.html

But let's take the analogy as it stands to its logical conclusion. If someone asks, "Which direction must I travel to get to the North Pole?" and you give him an answer that's 10, or 16, or even 18 degrees off, are your directions really going to get him "close" to his destination? Well, if you started at Sungenis's home in Pennsylvania and headed off with a supposedly "close enough" error of 16 degrees, you'd miss the North Pole by well over 900 miles. One can imagine that an arctic explorer who asked for directions that "point directly" at the North Pole "like an arrow" might be found cursing Sungenis's "close enough" misalignment when he finds himself more than 900 miles from his provisions.

Now let's use Sungenis's own verbiage about navigating from the edge of the universe:

So if one follows the CMB by staring [sic] at the edge of the universe (where the CMB originates) and follows it for 45 billion light years (the presently believed radius of the universe) and it got you to within 5 to 10 degrees or so of the Earth (the median of MacAndrew's claims for the alignment), don't you think that would be a close enough "position,." especially since geocentrists hold that the Earth is geometrically off-center with the edge of the universe? To arrive within 5 to 10 degrees of the Earth (which you already know is off-center in the Neo-Tychonic model) when you started your journey some 45 billion light years away is astounding! (*ibid.*, p. 13).

This is utter nonsense. Sungenis starts with the fundamental misunderstanding that the CMB vectors “point” to something (they don’t), compounds it with the misunderstanding that you could navigate from them (you can’t), but then just shrugs off the fact that being off by 10 degrees over a path of 45 billion light years would have you missing your target by over 7.9 billion light years! Sungenis and DeLano hold as a matter of faith that the Sun is the no-fooling geometric center of the entire universe and that the Earth is only 93 million miles away from this center. Now, suddenly, a miss by 7.9 billion light years is “close enough”? Incredible.

Geocentric claim #4: The misalignments are actually expected in the geocentric universe.

> **Unexpected by me…. by everyone I know …by everyone I’ve read ..**
> **Even now MS is desperately struggling top drum up an explanation based on the current LCDM model.**

Reality: This is merely *ad hoc* hand-waving, not a reasoned answer. Sungenis says that because the sun is offset from the earth they would expect there to be large misalignments in the CMB!:

Now, let’s say a little more about Mr. Palm’s accusation that God is a “sloppy architect” if God actually intended to align the universe with the Earth and Sun. In the geocentric universe, the Earth is not at the geometric center of the universe, but is off to one side by one astronomical unit, or 93 million miles. The universe is centered on the Sun, and thus the Sun would be closer to the geometric center of the universe, not the Earth. This is the very reason that the Bible never says that Earth is in the center of the universe, but only that it does not move. Why? Because the Earth is the center of mass for the universe, and the center of mass, as opposed to the geometric center, does not move. The entire universe follows the motion of the sun around the Earth because the center of mass for the universe coincides precisely with the center of mass of the Earth. In regards to the CMB, our model shows that the CMB alignments with equinoxes and ecliptic are the result of the annual Coriolis force created by daily rotation of the universe. Hence, if we calculate the slight off-centered position of the Earth with the universe, we will see the slight off-centered alignments of the CMB against the Earth. So, it is no surprise to the geocentrists that the alignments are not exact; rather; they are very close to the Earth's equator and the Sun-Earth ecliptic and is what we would expect in a Neo-Tychonic universe (*ibid*., pp. 7-8.).

This should come as a surprise to any geocentrist who has been following Sungenis and Company for any time, because they have never said one word about any "expected" misalignments in the CMB. Until Dr. MacAndrew pointed out the misalignments the verbiage was "point like an arrow" and "directly at the Earth" and "exact center". Now, suddenly, Sungenis changes his story and significant misalignments are not only not a problem, but something they expected all along. Notice, however, that there were no calculations to back up this fabricated, *post hoc* claim — and there never will be. As with all geocentric claims, it's pure hand-waving.

It's interesting too to note the blatant double-standard involved here. Sungenis insists that misalignments of 14, 16, even 23 degrees present no problem for his claims. But he insists that anomalous alignments in tiny anisotropies in the CMB absolutely sound the death knell for the Standard cosmological model. He blatantly misrepresents just how large the anisotropies themselves are:

let's, for the sake of argument, agree that the universe is 95% isotropic and homogeneous. What about that other 5%? How significant would that be in studies of this nature? Pretty big (*ibid*., p. 5).

In reality, as Dr. MacAndrew has documented, the "intrinsic" anisotropies are about one part in 100,000 or 0.001% (see "The CMB and Geocentrism", p. 14). Even the biggest anisotropy in the CMB, which arises from the Doppler shift of the motion of the solar system with respect to the CMB is about one part in 1,000 or 0.1%. According to every measure, the Universe is highly isotropic. So again we find yet another blatant double standard in Sungenis's "scientific" rhetoric, with Sungenis attempting to downplay these significant misalignments of 14, 16, even 23 degrees as trivial for his own views, while at the same time playing up the expected and vastly smaller anisotropies in the CMB as devastating for his opponents by simply fabricating numbers that are different from those observed by a whopping factor of *5,000*.

Conclusion:

The new geocentrists have for years been making extravagant claims concerning the alignment of the CMB vectors, claiming that they “point like an arrow . . . directly to the Earth”, “point directly to the Earth as the center”, and “show that the whole Universe is centered on the Earth”. Their claims are based on a fundamental misunderstanding of the information conveyed by *the CMB vectors, which give directional but not positional information.*

Repeat the off-center paper conclusion….

And to compound their difficulties we find that the CMB vectors are significantly misaligned from the ecliptic and the equinox.

Rather than simply admit both their misunderstanding of the science and their misrepresentation of the alignments, the geocentrists have instead chosen to “double down” and deploy a bunch of ad hoc “explanations” that further demonstrate both ignorance and incompetence.

The new geocentrists have bamboozled any number of unsuspecting folks into believing that they really know the science. But once again we see that their fundamental claims are based on a profound misunderstanding of the scientific views they purport to be competent to challenge and even correct. The geocentric hype concerning the CMB shows that they are propagandists first, media manipulators second, but scientists never.

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http://www.geocentrismdebunked.org/the-cmb-and-geocentrism/

The CMB and Geocentrism

by Dr. Alec MacAndrew (20 October 2014)

Alternate title: Alec in Wonderland

McA focuses on CMB …ignores the other sky symmetries…star dist, galaxy rotation,

That Shepherd, who first taught the chosen Seed
In the Beginning how the Heav'ns and Earth
Rose out of Chaos – John Milton
If life is going to exist in a Universe of this size, then the one thing it cannot afford to have is a sense of proportion… – Douglas Adams

1 Introduction

The New Geocentrists have been claiming for some time that recent measurements of certain cosmological features "point straight at the Earth"[1], and that therefore the Earth must be in the centre of the Universe. More recently, they have been promoting their movie, *The Principle*, which they hype as "one of the most controversial films of our time"[2]. The movie is ostensibly about a "fair, balanced and comprehensive treatment" of the Copernican Principle – the proposition that the Earth is not in a central or favoured position in the cosmos. Of course, it is well known that the movie's principals, Robert Sungenis and Rick DeLano, are strict geocentrists who believe, for religious reasons of their own, that the Earth is absolutely static and located at the exact centre of the Universe. Strict geocentrism has been superseded for centuries – and there are clear modern refutations of the idea[3]. Strict geocentrism is also a far more extreme position than would necessarily follow if the Copernican Principle were to be violated. It is clear that *The Principle* movie is a Trojan Horse for strict geocentrism, even though DeLano in particular claims that the film contains no more than an examination of the Copernican Principle.

Chief amongst the recent cosmological measurements that geocentrists highlight in support of their case are certain anomalies in the Cosmic Microwave Background (CMB), the afterglow of the Big Bang. This article describes the science of the CMB, reviews the anomalies, and discusses what implications they have for cosmology in general and for the claims of the geocentrists in particular. We'll also briefly review some other theories and observations that have the potential to challenge the Copernican Principle, and consider what implications they might have. In this article, I hope to provide a resource for thoughtful people who are unsure about the strength of the claims that the geocentrists make about modern cosmology, to help them to a better understanding of the science and what it actually implies.

The geocentrists approach to the issue is deeply unscientific, in the sense that they are committed *a priori* to the idea that the Earth is static in the exact centre of the Universe, and they excavate and use any piece of evidence that appears to support their case – even if it is fundamentally incompatible with some other argument that they have made elsewhere. Their belief is unshakeable in the face of any and all evidence to the contrary. What's more, by misunderstanding or misrepresentation they often mangle the science, and they make far stronger claims than the evidence warrants, as we shall see.

The scientific approach is different: scientists attempt to build self-consistent models of the Universe. They try not to use arguments that are incompatible with others they use, or with observations, and they try to avoid making strong claims that are not warranted by the evidence. They also try to be open to the possibility that they might be wrong and that they need to follow where the evidence leads. As scientists are human beings, they don't always live up to these ideals, but I believe that the community as a whole does succeed.

In this *article I will do my best to present a fair and balanced overview of the observations and what they could mean for our understanding of the Universe and for the geocentrists' claims.*

The effort is appreciated, but lack of foundation in philo – esp metaphysics and logic and epistemology – clouds the analysis with subjective science and hidden agenda

However, a fair description of the experimental observations and a cautious assessment of what they mean have resulted in arguments in this article that can be somewhat nuanced, complex and technical. I will try to keep the discussion as simple as I can but we will necessarily be led into more complex issues. If you are interested only in rhetorical one-liners in support of either side, this article is probably not for you. And whether or not you agree with my conclusions, I hope that you will learn something about the science that underpins modern cosmology.

2 What is the CMB?

2.1 The CMB predicted

I have described the Cosmic Microwave Background as the afterglow of the Big Bang, so let's look at the evidence that supports that assertion.

There were two leading cosmological models in the middle part of the 20th century, of which the Big Bang idea was one[4]. Msgr Georges Lemaître had proposed the concept of the Big Bang in 1927 (although it wasn't called that then) and it received substantial support in 1929 when

Edwin Hubble discovered that the distances to galaxies were correlated with red-shift, meaning that the further away a galaxy is, the faster it is receding from us.

Red-shift refutation…..

Taken in conjunction with solutions developed by Alexander Friedmann to the Einstein field equations of General Relativity, which describe the *evolution of a homogeneous and isotropic Universe, Hubble's discovery was evidence for a Universe that was expanding everywhere.*

GR already refuted.. Kills all further speculation…

McA leaves out the Copernican principle…

In such a Universe, you would observe galaxies receding faster the further away they are, regardless of your location in the Universe. If you look back in time in such a Universe then you arrive at a moment when all the mass and energy of the Universe is concentrated into a density that is so great that its behaviour cannot be predicted by currently known physics – this is the famous singularity that precedes the Big Bang.

The hypothesis that the Universe has a finite age and that it began with the Big Bang predicts that in its early stages it would have been immensely hot and would have contained a large quantity of radiant energy in the form of short wavelength photons. In the early Universe there was a period when the temperature was so high that electrons were unable to bind to protons to form neutral atoms. The photons of the early intense hot radiation were unable to travel very far before being scattered by the free, unbound electrons[5]. At some time later, the Universe cooled and expanded sufficiently so that the photons became able to stream freely across space (this event in cosmic history is known as "decoupling", because photons and matter became decoupled at that time – subsequent measurements indicate that this occurred about 380,000 years after Big Bang). Cosmologists therefore predicted that the entire Universe is filled with these photons, which have been travelling freely across space since that time.

The theory also predicts that this radiation has a black body spectrum. The spectrum of a source is the intensity of the light as a function of wavelength; a "black body" absorbs all light incident on it and emits light with a very specific spectrum given by Planck's law, where the peak of the spectrum (i.e. the wavelength with the highest intensity) is determined by the temperature of the body – in hotter bodies the spectrum is shifted to shorter wavelengths and in cooler bodies to longer wavelengths – see

Figure 1. The Big Bang theory predicts that the photons of the early Universe would have an almost perfect black body spectrum.

The Big Bang theory also predicts that the primordial radiant energy will have been greatly cooled by the expansion of the Universe since the time of decoupling. This process maintains the black body spectral characteristics of the primordial radiation but shifts the spectrum to a much lower temperature. So, we should expect to find the Universe permeated by low temperature, long wavelength radiation possessing a black body spectrum.

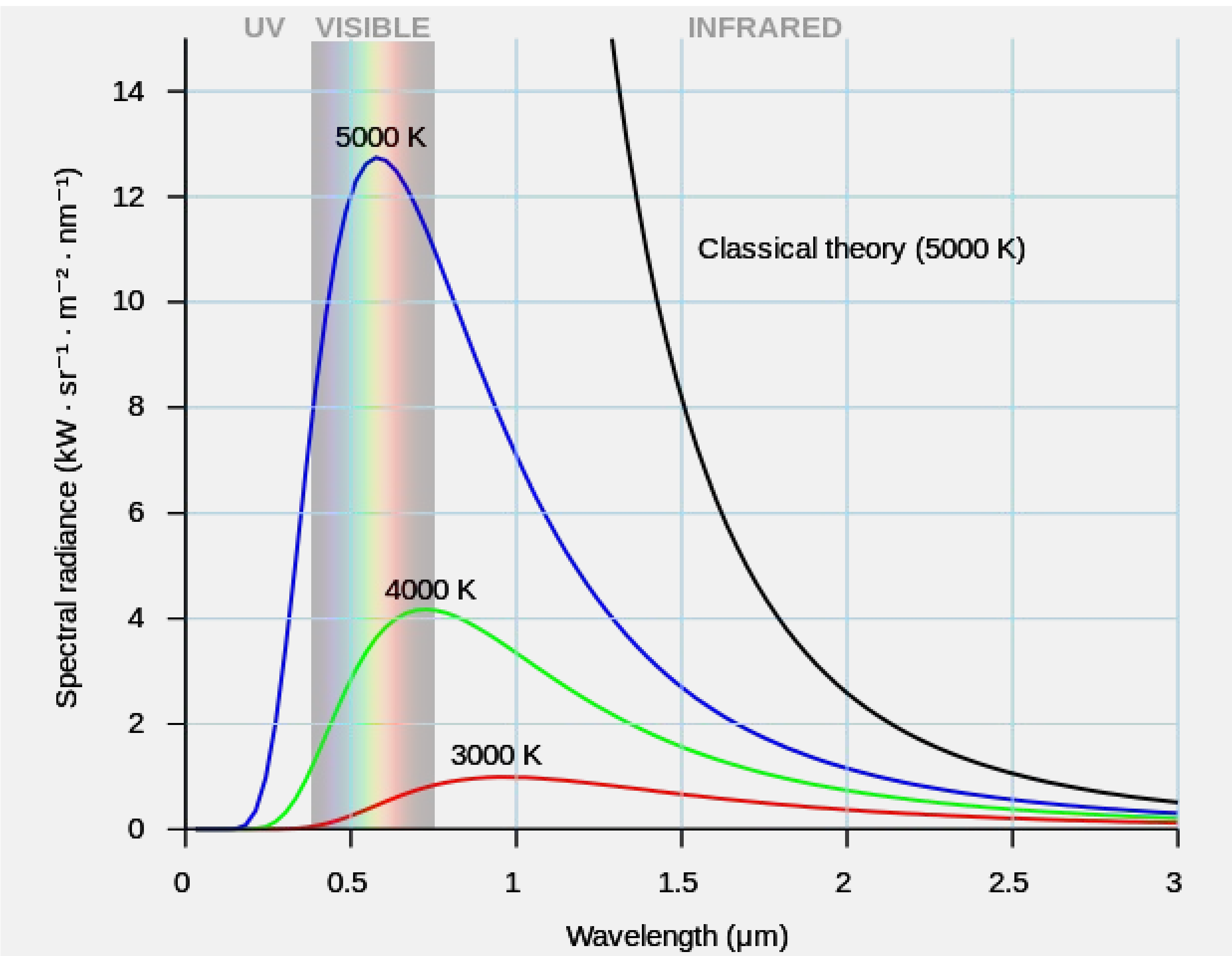

Fig 1. Three black body spectra at 3000K, 4000K and 5000K showing how the spectrum is shifted to longer wavelengths for cooler sources. The black curve shows the classical prediction for the spectrum of a black body, which does not match observations. In Planck's theory the energy of radiation is quantised and the theory correctly predicts the black body spectrum. Source: Wikimedia Commons

These predictions were originally made by Ralph Alpher and Robert Hermann in 1948, forgotten, and then re-published by Robert Dicke and Yakov Zel'dovich in the early '60s.

2.2 Discovery of the CMB

In 1964, Arno Penzias and Robert Wilson of Bell Labs started work with a particular design of radiometer – a sort of telescope that can detect microwaves; microwave radiation is very long wavelength electromagnetic radiation. The radiometer was originally designed and built to communicate with satellites, but that function had become obsolete. They planned to use it for radio astronomy in the microwave part of the spectrum. Stars and other celestial bodies emit electromagnetic radiation right across the electromagnetic spectrum from short wavelength gamma rays to long wavelength microwaves, so astronomers are interested in all wavelengths.

Penzias and Wilson detected a signal that appeared to come from every part of the sky. At first they believed that it was an artefact of their instrument – the story goes that they spent days cleaning pigeon droppings off it in an attempt to get rid of what they originally thought was unwanted noise. However, it soon became clear that the signal was real and cosmological in origin.

The signal was very uniform across the sky – it appeared to be the same intensity in whatever direction they looked and subsequent measurements at different wavelengths confirmed that it had a perfect black body spectrum. In fact, this radiation "has the most perfect black body spectrum ever measured".

It was soon clear that they had detected the radiation predicted by Alpher and Hermann, and Penzias and Wilson were awarded the Nobel Prize for physics in 1978. The radiation became known as the Cosmic Microwave Background (CMB) and its characteristics were about to reveal a great deal about the early Universe.

CMB misinterpreted.... Radiation predicted by alpher and hermann and gamow did not match CMB..

CMB: remnant radiation of stars pouring out energy into space since creation..

Projection back 13.5 giga yrs violates the SM testability rule….

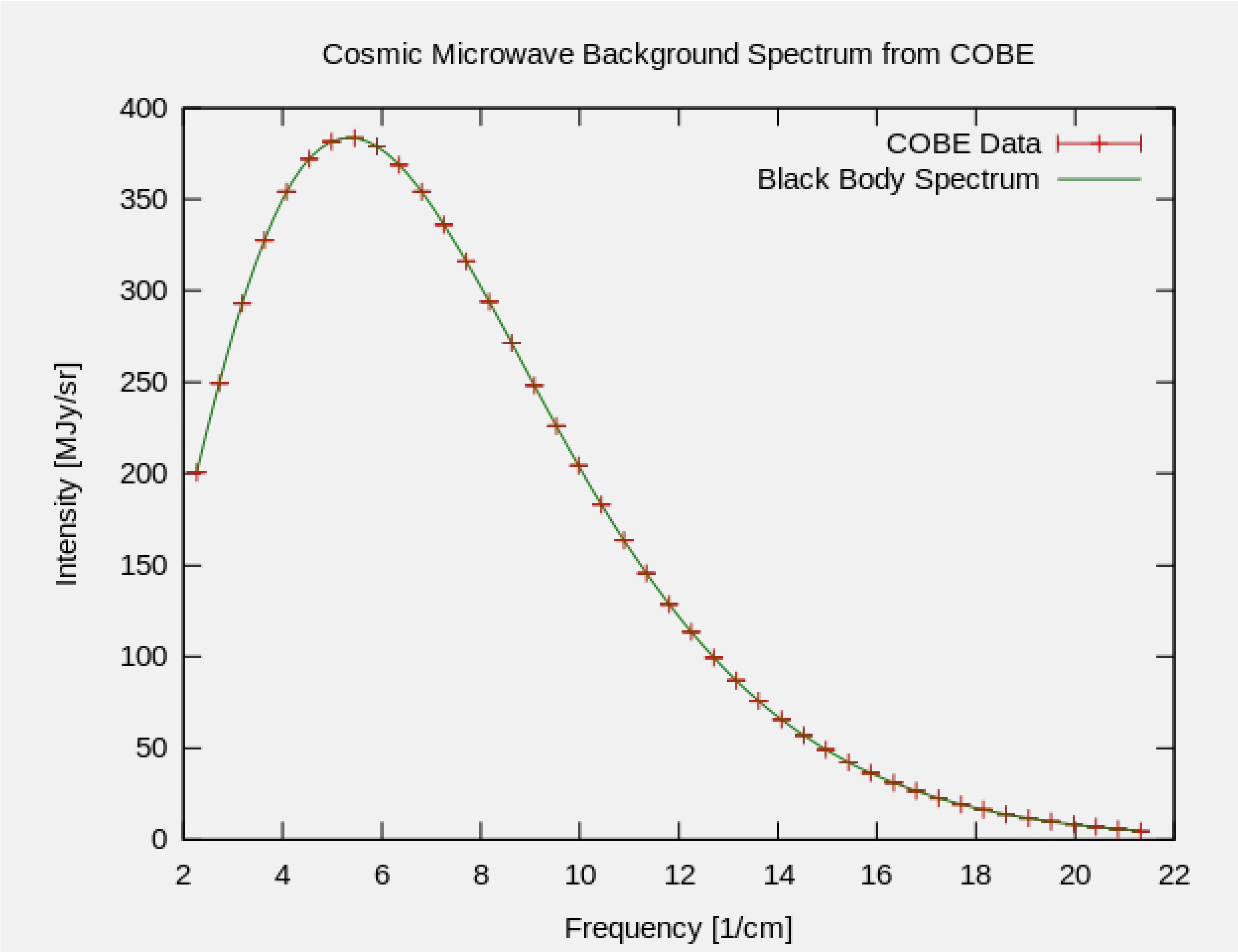

Fig 2. The most perfect black body spectrum ever measured. The spectrum of the CMB measured by the COBE satellite. The data points are indistinguishable from theory and the error bars of the measurement are too small to plot. Source: Wikimedia Commons

2.3 Characteristics

The temperature of the CMB is 2.73K, or just 2.73° above absolute zero. As the temperature of the early Universe dropped to below 3000K, there were not enough sufficiently energetic photons to prevent the electrons from binding, and the free electrons were captured by protons to form hydrogen atoms (each neutral hydrogen atom consists of one proton, the nucleus, and one bound electron), which allowed the primordial radiation to propagate freely. This process is called “decoupling” or “last scattering”. The temperature of the CMB at the time of decoupling was therefore about 3000K, and the Universe has expanded by a factor of about 1089 since that time (The theory indicates that the temperature is inversely proportional to the scale factor, which is a measure of how much the Universe has expanded).

The temperature of the CMB is extremely isotropic – in other words, it looks the same in all directions. It is very important to understand just how uniform the CMB is.

The fact that the CMB is so isotropic is good evidence for the Cosmological Principle that states that the Universe is homogeneous and isotropic on large scales.

Use all the CMB alignments and anomalies to refute…

View by andy Andromeda would see the local MWay architecture ….

However, the temperature of the CMB is not completely uniform and there are random fluctuations or variations of the order of one part in 100,000, or about 18μK (18 millionths of a degree). These fluctuations are known as anisotropies in the CMB – departures from perfect isotropy (isotropy means that something looks the same in all directions). If the CMB is ancient radiation that arises from the early Universe, then how do these anisotropies arise and what can they tell us about the cosmos?

The basic pattern of anisotropies is predicted to arise from primordial quantum fluctuations in the very early Universe[6]. Quantum theory predicts that the early Universe would not have been completely uniform but that there would have been random variations in density. Such variations in density would have survived through the early epoch of the Universe prior to decoupling and in fact would have been modified by the behaviour of the early Universe in a way that provides us with information about the make-up and behaviour of energy and matter prior to decoupling. Those parts of the CMB that arose from regions of higher density would be cooler, compared to parts of the CMB that arose from less dense regions[7]. These are called primary anisotropies.

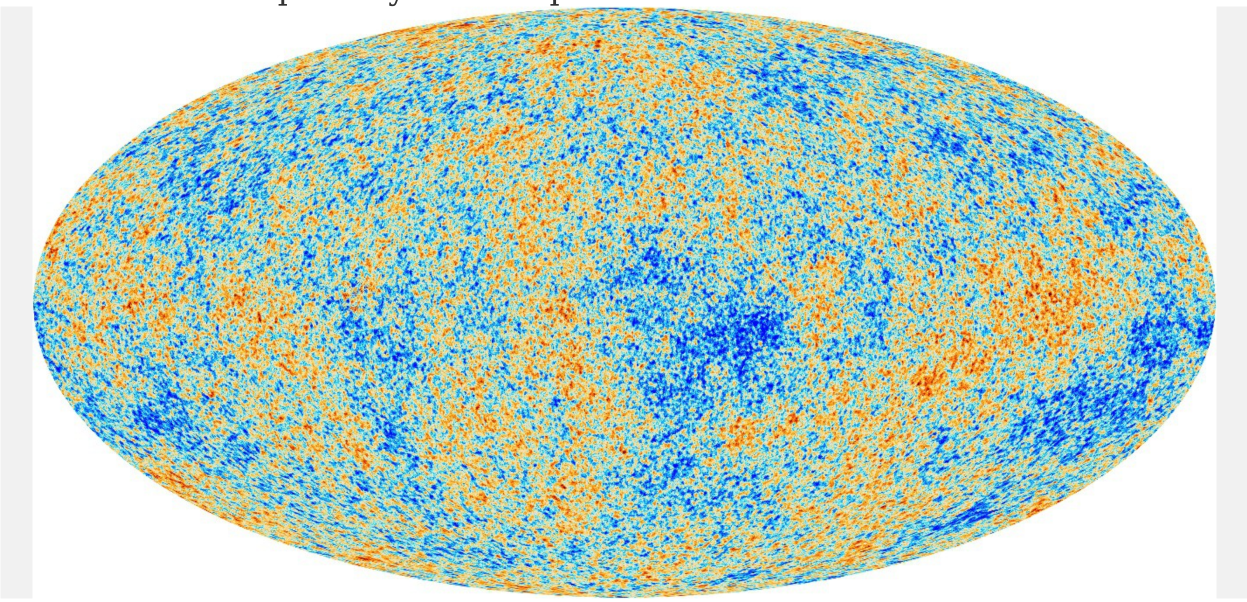

Fig 3. A cleaned full sky map of the Cosmic Microwave Background from the Planck10 mission showing temperature anisotropies – hotter regions are coloured red, and cooler regions blue. Source: ESA; Planck Collaboration

There are also anisotropies in the CMB that arise after decoupling – processes that affect the temperature and paths of the CMB photons as they stream across the Universe. An example of this is known as the Integrated Sachs-Wolfe effect: the CMB radiation temperature is gravitationally affected by the photons' passage through or near to massive structures such as galaxies or galaxy clusters. These are called secondary or late anisotropies.

Turning back to the primary CMB anisotropies, the statistics of the fluctuations carry a great deal of information about the processes that took place prior to decoupling. As you will remember, the Universe was opaque to radiation prior to decoupling and so it seems surprising that we can see what was taking place in the Universe then. However *the processes that occurred imprinted certain patterns of temperature fluctuation on the CMB at the time of decoupling*

refuted by local patterns…

and so allow us to look through what seems at first sight, an opaque and impenetrable curtain.

2.4 The statistics of the CMB

We have seen that the temperature fluctuations in the CMB are random, and it is the statistics of those random fluctuations that allow us to probe the Universe before and after decoupling. The quantum theory of the Big Bang predicts that the primordial fluctuations were Gaussian and nearly scale invariant. The statistics of the CMB temperature fluctuations reflect this Gaussian and near scale invariance. So what do Gaussianity and scale invariance mean? Gaussian statistics means that the temperature fluctuations in the CMB should follow a Gaussian or bell-curve distribution as in Fig 4. The bell curve is centred on the mean temperature of 2.73K and the probability of measuring a particular temperature at any point on the sky is given by the curve. The percentages show how much of the distribution falls within that segment of the curve.

The original quantum fluctuations are also predicted by quantum theory to have been nearly scale invariant – that is the density fluctuations in the primordial plasma would have had almost the same amplitude at all scales. (Subsequent physical effects that occurred after Big Bang and before decoupling have intensified the fluctuations at some scales while suppressing the fluctuations at other scales.) *A modest deviation from scale invariance in the primordial fluctuations is evidence for cosmic inflation*

Inflation: untestable ala SM….

(see Section 3 below on the Standard Model).

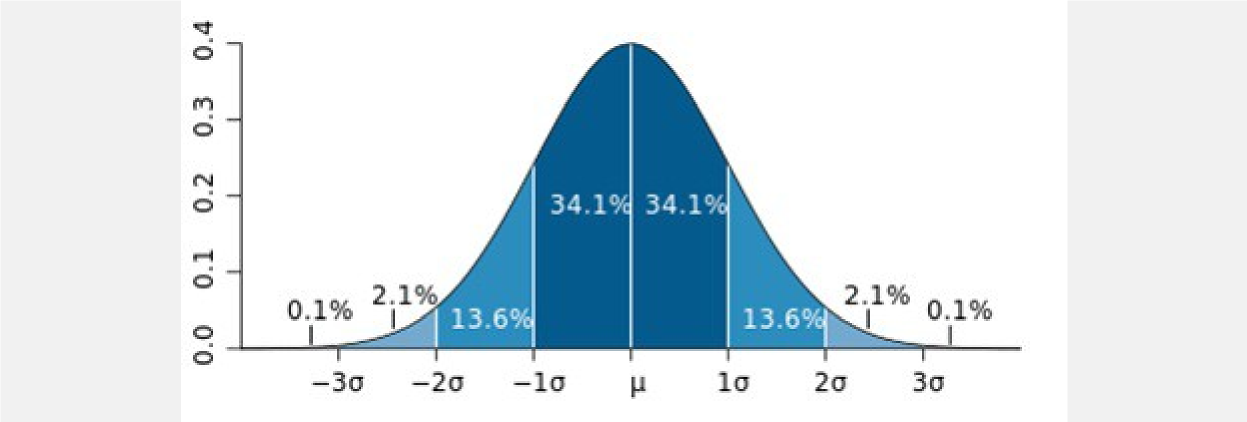

Fig 4. A Gaussian distribution. In the case of the CMB the vertical axis is probability of that temperature and the horizontal axis is temperature in degrees K where μ is 2.73K and 1σ is ~18μK. Source: Wikimedia Commons

The distribution of the temperature fluctuations in space, across the sky, can be characterised by decomposing the whole sky temperature map, as in Fig 3, into spherical harmonics also known as spherical multipoles. We do this in order to see how the amplitude of the temperature fluctuations varies according to their scale. This is analogous to the well-known decomposition of a one-dimensional signal into discrete Fourier components[8]. The full anisotropy map is made up of a series of discrete spherical multipoles, where these multipoles are characterised by increasing numbers of lobes equal in number to integer powers of two (2, 4, 8, 16 etc.). These multipoles start at l=0 (which is the basic temperature of the CMB at 2.73K), and continue through l=1 (the dipole, in which there are two lobes on the sky, where one lobe is hotter than the other), l=2 (the quadrupole with four lobes interleaved,), l=3 (the octopole with eight lobes interleaved), and so on indefinitely. In principle there are an infinite number of multipoles making up the CMB anisotropy. If we add together all the multipoles we would reconstruct the original full sky map as in Figure 3.

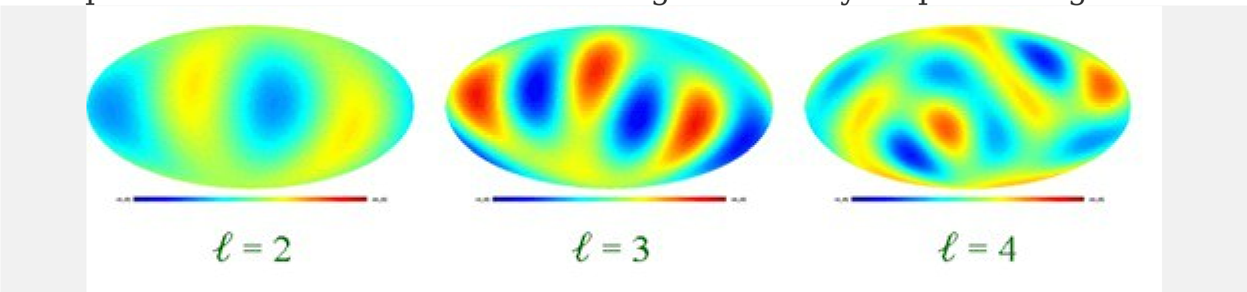

Fig 5. The quadrupole, octopole and hexadecapole of the CMB where the extreme colours represent ±50μK. Source: NASA WMAP 3 Year ILC Map

I've already mentioned that the primordial Gaussian, nearly scale invariant fluctuations are modified by events that took place in the Universe in the epoch before decoupling, so we'll look now at what those events were. For 380,000 years after Big Bang, the Universe consisted of a plasma of baryons (protons and neutrons) and radiation, the so-called photon-baryon plasma. Matter was gravitationally attracted to regions of slight over-density, whereas the interaction of radiant energy with matter in those regions created a pressure that tried to push the matter apart. The resulting tension caused density waves, similar to sound waves with which we are all familiar. The detailed theory of this epoch of the Universe[9] predicts that these "sound waves" (known as Baryon Acoustic Oscillations or BAO) intensified regions of over- and under-density in the Universe. The speed of sound in the baryon-photon fluid was about 0.58x the speed of light. These oscillations occurred at a wide range of scales because of the scale invariance of the original fluctuations in density that gave rise to them. The oscillations occurred for a finite time from the Big Bang to decoupling, about 380,000 years later, after which the pressure from the photons ceased when the electrons combined with protons to form neutral atoms and the photons were able to propagate freely across space. At that time the variations in density in the fluid were imprinted on the temperature of the photons – hotter where the photons arose from regions of lower density and cooler from regions of higher density[7], and these photons are the ones that we detect now in the CMB.

If we consider which scale had the greatest variation in density at the time that the density fluctuations were imprinted on the CMB then we can see that this is the scale that accommodates a single compression cycle in the time available. At other scales, the oscillations would have been part way through a compression-rarefaction cycle at the time of decoupling and therefore would have had less amplitude. Theorists therefore predict that the BAO structure would have maximum amplitude at a scale at decoupling known as the sound horizon – the distance sound waves could travel across the Universe in the 380,000 years between Big Bang and decoupling. After decoupling, the photons are free to stream away across the Universe carrying the imprint of the acoustic oscillations with them. These acoustic oscillations, the ringing of the early Universe, can be seen in the statistics of the CMB anisotropies. Taking the expansion of the Universe into account, theorists predicted that the first peak in the anisotropy power spectrum (the plot that shows the intensity of each multipole versus multipole number) would occur at about multipole l=220, which subtends approximately 1° on the sky. The exact location of the measured peak and the angle that the peak multipole measures on the sky gives us information about the geometry of the Universe, indicating that it is flat or nearly so.

The CMB anisotropies contain much more information. For example, the second peak in the anisotropy spectrum carries information about complete cycles of compression and rarefaction in the acoustic oscillations and the ratio of the amplitudes of the first and second peaks tells us about the density of matter and the ratio of matter to radiation.

In addition to these primordial anisotropies, the CMB is also affected by its propagation across the Universe for 13.8 billion years, and carries other information about the Universe structure in anisotropies that have been created since decoupling – the so-called late or secondary anisotropies, which include gravitational red and blue shifting (the Integrated Sachs-Wolfe effect), increased photon energy caused by scattering off high energy electrons (the Sunyaev- Zel'dovich effect) and gravitational polarisation. These effects also contribute to our cosmological knowledge.

The fact that the

CMB is the oldest light in the Universe

No proof…. SM testablility ??   could have accumulated since creation.

and is very uniform across the sky is interesting in itself, but the very faint anisotropies in the CMB, which open a window to the primordial Universe, are the key to cosmologists' interest in the subject.

2.5 Probing the CMB

Because the CMB consists of such ancient light and because it carries so much information about the early Universe, there have been many experiments to measure it. The most well-known are the three satellite experiments, COBE[10] (1989 – 1996), WMAP[11] (2003 – 2010) and Planck[12] (reporting at the time of writing). These satellites measured the CMB anisotropies across the entire sky. Each satellite was able to measure the CMB with greater precision and in finer detail than its predecessor.

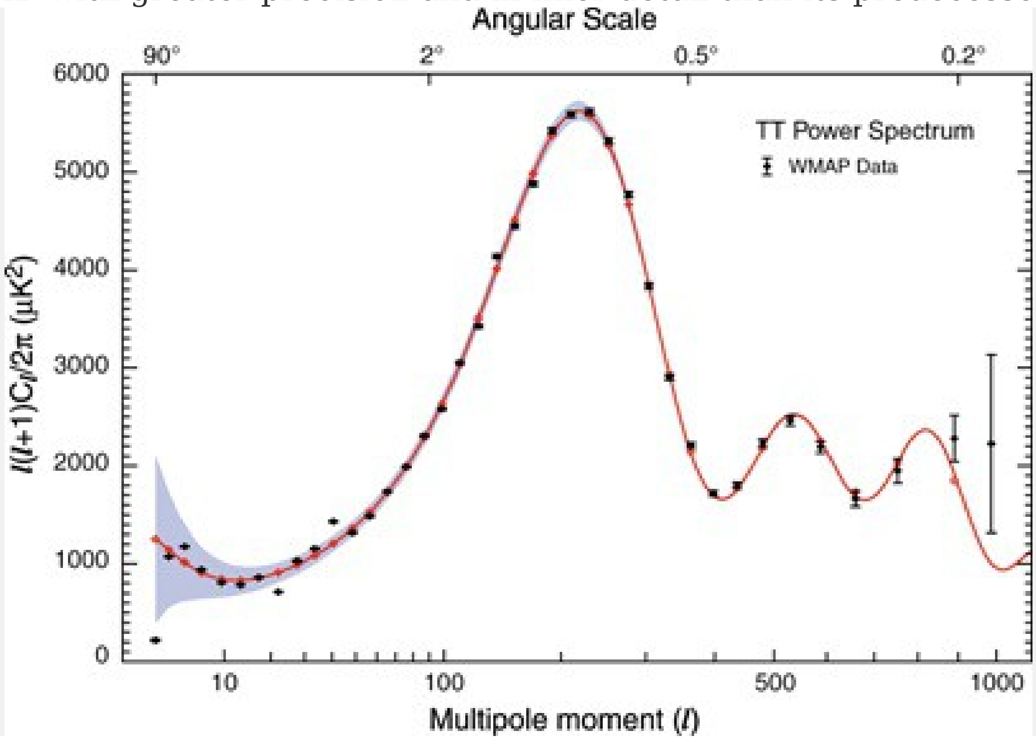

Fig 6. The three-year WMAP CMB power spectrum. The vertical axis represents the amount of anisotropy and the horizontal axis represents the scale, with large scale modes towards the left and fine scale modes to the right. The theoretical prediction of the standard ΛCDM model is the red curve and the experimental data are the black points with error bars. Source NASA/WMAP Science Team

COBE confirmed the very high homogeneity, isotropy and Gaussianity of the full sky CMB, and was the first mission to detect the predicted anisotropies. However, its resolution was insufficient to measure the first acoustic peak predicted at l = 220. The first acoustic peak was first measured by two high altitude balloon experiments (BOOMERanG[13] and Maxima[14]), which measured the anisotropies in the CMB beyond l=220 over a small area of the sky.

WMAP gathered data over nine years and confirmed that the first acoustic peak was at l ≈ 220 as predicted. Many details of the WMAP detailed measurements were consistent with the Standard Model of cosmology (the Big Bang, inflation, dark energy, cold dark matter model).

The European Space Agency operated the Planck satellite between 2009 and 2013. The first year results were published in 2013 with more results, and in particular the polarisation data, expected in 2014. With a greater resolution than WMAP and higher precision radiometers, Planck was able to measure the CMB anisotropy out to l = 2500 which is equivalent to 0.07° or about 4 arcmin scale on the sky. Planck provided greater precision than WMAP but the basic conclusion it reached is the same – the CMB data fits the standard ΛCDM model (see Section 3 below) very closely indeed. The overview paper states[15]:

"Scientific results include robust support for the standard, six parameter LCDM model of cosmology and improved measurements for the parameters that define this model, including a highly significant deviation from scale invariance of the primordial power spectrum." The modest but significant deviation from scale invariance is evidence for cosmic inflation.

Check claims of 6 parameters..more like 16???

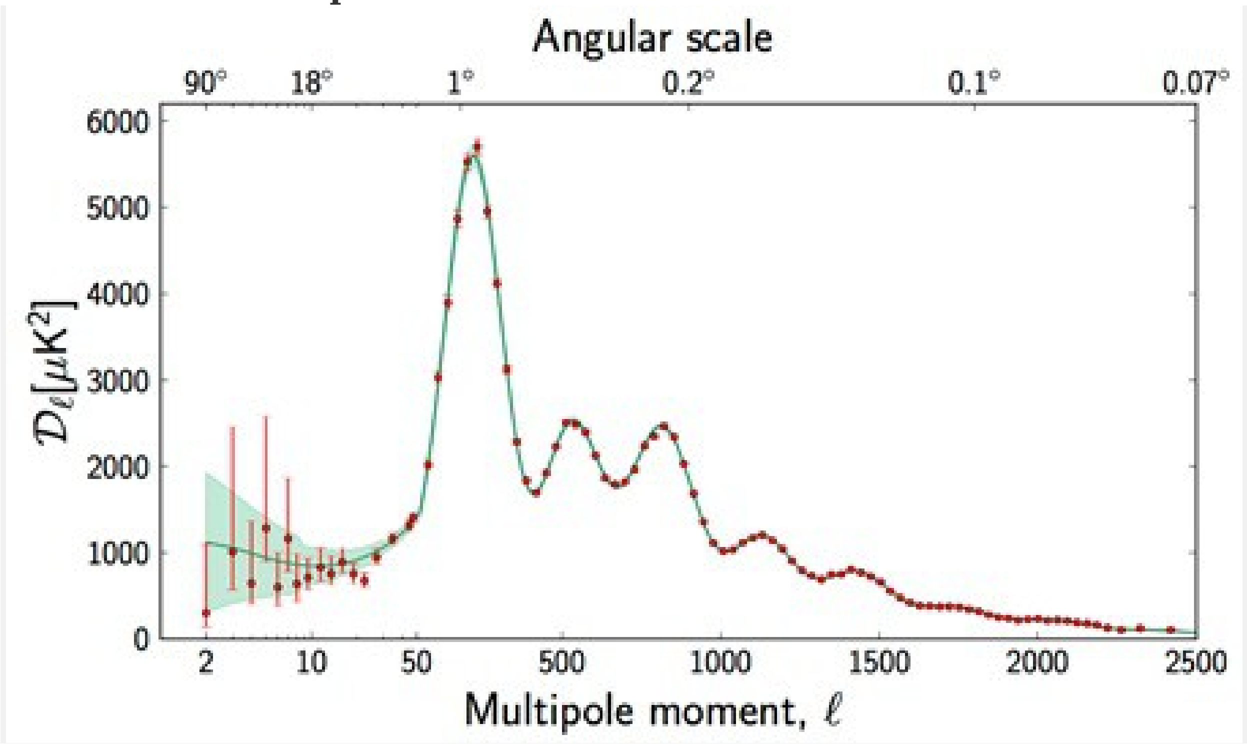

Fig 7. The Planck CMB power spectrum. The best fit ΛCDM model is the green curve and the shaded area shows cosmic variance (the statistical variation expected in the best fit model from one observational location in the Universe to another). The data points and error bars are red. The measured CMB matches the six-parameter ΛCDM model closely across all seven peaks. Source: ESA and the Planck Collaboration

The paper also points out that the Planck data is highly consistent with other observational data such as Big Bang Nucleosynthesis[16] and states "The predictions of the baryon density from these two methods involve all of the known forces of nature and this highly non-trivial consistency provides strong evidence for the universality of those laws."
So, a key finding of these measurements of the CMB by the WMAP and Planck satellites, along with other CMB measurements made from high altitude balloons and ground based microwave radiometers is that

the CMB anisotropies fit the Standard Model of cosmology to an extremely high degree of accuracy.

Research and refute in detail…

3 Standard Model of the Universe
In this section we'll look at what is known as the Standard Model or Concordance Model of cosmology. There is a very powerful consensus that the Standard Model is a good approximation to the observable universe, although most if not all cosmologists would agree that it is not correct in every detail and that it needs to be refined.

3.1 The Copernican and Cosmological Principles

The Standard Model starts from the assumption that *what we observe of the Universe is typical of what would be observed from any vantage point – this assumption is based on the Copernican Principle, and its more stringent version, the Cosmological Principle.*

Cite all conflicting reasons and papers

The Copernican Principle proposes that the Earth is not at a central or otherwise special or privileged place in the cosmos.

Galileo observed other solar planets with their moons orbiting the Sun and concluded that the Earth was also a planet orbiting the Sun.

Tychonian model explains this

In the 20th Century, astronomers looked out to the distant Universe through land-based and satellite telescopes such as the Hubble Space Telescope and observed a vast quantity of galaxies. We came to understand that

the Sun is just one of a huge number of entirely unremarkable stars that make up the Milky Way Galaxy, which itself is just one of a huge number of spiral galaxies in the observable Universe.
No star has been directly observed and tested . suns and star equivalence is a guess. All we have is a faint light beam…. And lots of imaginative speculation.

Current estimates suggest that there are about 100 billion stars in the Milky Way and between 100 billion and a trillion galaxies in the observable Universe.
Our observations support the Copernican Principle.
No evidence for this raw assertion.

The Cosmological Principle goes further and makes a more precise and stringent claim: *the Cosmological Principle states that the Universe is homogeneous (it has a similar structure everywhere) and isotropic (it looks the same in all directions no matter from where you observe it).*

Assumes a broad enough view that the great wall and voids and shells surrounding us would be indistinguishable at large enough distance… Untestable…

Plus all the CMB anomalies…

The Standard Model assumes homogeneity and isotropy on the very largest scales – obviously on the scales of galaxy clusters and the intervening voids the Universe is not homogeneous – there is clumping of matter into stars, galaxies and galaxy clusters that violates homogeneity and isotropy on those scales

Admitted contrary evidence.

and *the Standard Model actually explains why that is.*

Where?

The very high uniformity of the CMB is evidence for the Cosmological Principle, and the Standard Model largely accommodates and predicts the departures from strict isotropy that are observed.

3.2 General relativity and the FLRW metric

All of GR is rejected..

The best current theory of gravity is Einstein's Theory of General Relativity (GR). It is based on the Einstein field equations first published in 1915 that describe how mass and energy in the Universe distorts space-time and how the distortion of space-time affects the motion of matter and the propagation of radiation. In order to use GR to describe phenomena and make predictions about the Universe, scientists must find solutions to the field equations for various specific circumstances. The solution that is the basis for the Standard Model of cosmology is the Friedmann-Lemaître-Robertson-Walker metric that describes an expanding or contracting homogeneous and isotropic Universe filled with a perfect fluid. There are many other cosmological solutions to the Einstein field equations, but many of these make unphysical predictions– in other words predictions that do not fit what we observe. The evidence gathered so far is that the Universe as a whole is well described by the FLRW metric but there is also some speculation that other solutions that describe modest departures from homogeneity correspond better to regions of the observable Universe – we'll discuss these ideas later.

3.3 Inflation

There were two cosmological problems inherent in the Big Bang model that remained unsolved up until the mid- 1980s[17]:

1. *The Horizon problem: there are parts of the observable Universe that are too far apart to ever have been in direct causal contact and yet the Universe is very homogeneous*
   An argument for an immediate creation of the observable universe all at once…in all places…everywhere.
2. *The Flatness problem: the geometry of the Universe is measured to be flat or nearly flat, which would require extreme fine tuning early on*
   a universe almost all empty space would be expected to be Euclidean (eevn in GR)

To resolve these issues, *Alan Guth proposed the theory of inflation*[18] *that states that the Universe went through a period of extremely rapid expansion by at least a factor of 10^{26} in 10^{-33} seconds just after Big Bang*.
Super ad-hoc…..and untestable, of course.

This would allow parts of the Universe, which are now very far apart, to have been in causal contact before the period of inflation; and it would provide a mechanism for creating a flat Universe without fine tuning. There are several different models for the inflationary process and for the field that is thought to have driven it. The favoured model makes a number of predictions about things that depend on inflation, which we can observe in the current Universe, and those predictions have been broadly fulfilled. This gives significant credence to the concept.

For example, inflation predicts that the anisotropies in the CMB and the large scale structure of galaxies originate from quantum perturbations in the inflation field. Quantum theory is the basis for determining the statistics of the perturbations. The CMB was predicted to be highly uniform, with small anisotropies that correspond to inflationary quantum perturbations. The predicted anisotropies are Gaussian and almost, but not quite scale invariant, as we saw in Sec 2.4 above. Measurements from COBE through WMAP and Planck, as well as large scale surveys of galaxies are in good agreement with the inflation predictions. Other predictions of inflation such as a flat geometry for the Universe and perturbations that are adiabatic[19] are also well supported by the data.
So, although *at first sight inflation seems to be a rather arbitrary hypothesis, spirited up to solve a few cosmological problems,*

And it still does…even worse with latest counter-evidence…

Research…

the theory does make very specific predictions that are closely confirmed by a range of observations.

3.4 Dark Matter

It has been known since the 1930s that the orbital characteristics of the Milky Way and the orbital velocities of galaxy clusters are such that much more mass is present than can be seen. The suggestion that *there is an exotic form of matter, which interacts gravitationally but does not interact through other physical forces and so cannot be seen, was made first by Fritz Zwicky in 1937[20].*

Ad hoc attempt to side-step aether effects ….

In the late 1970's and early 1980s, Vera Rubin and colleagues[21] made precise measurements of the speed of stars in other galaxies versus their radial distance from the centre of the galaxy (known as the rotation curve). They found that in spiral galaxies the speed of stars was approximately independent of distance from the centre of the galaxy (this is known as a flat rotation curve), whereas the distribution of mass in the galaxy determined by the luminosity of stars predicted that the speed of stars should reduce further from the galactic centre (see Fig 8). The observation can be explained if we postulate a large mass of non-luminous matter in the galaxy extending well beyond the central part of the galaxy where the majority of the stars are found[22]. The missing mass appears to be an exotic form of matter, called dark matter, which interacts only gravitationally with ordinary matter and radiation, and which has so far not been identified in the lab.

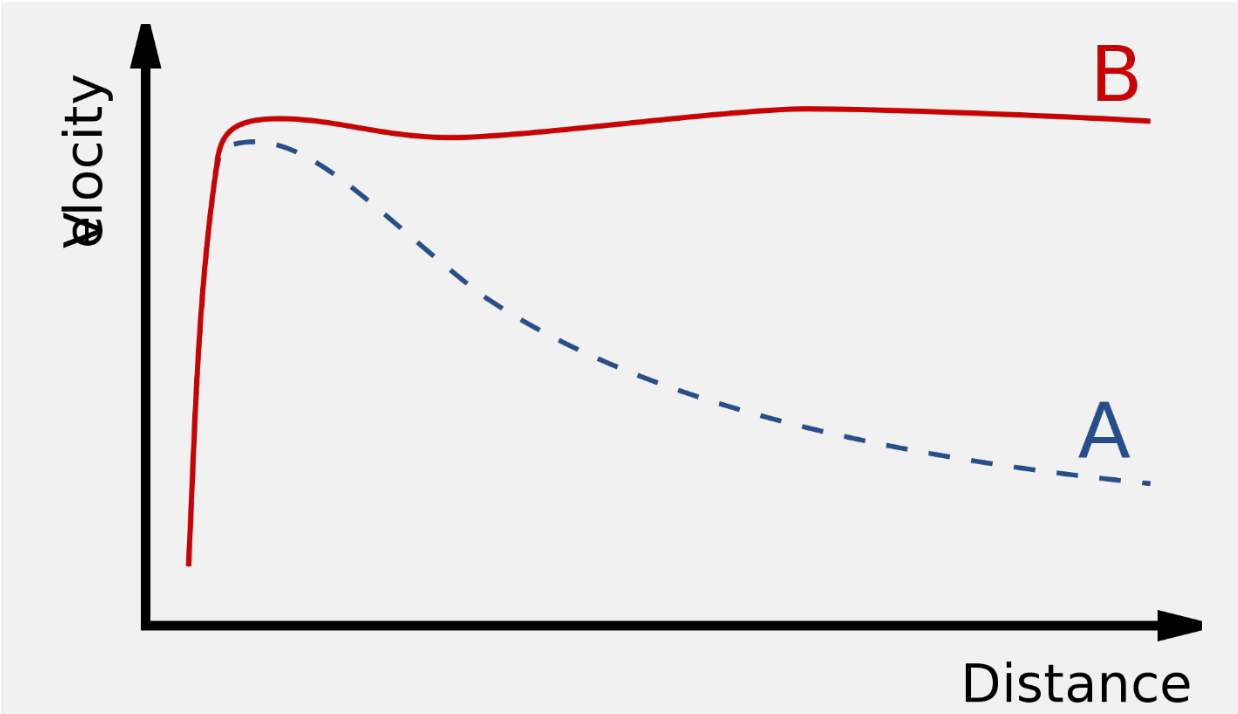

Fig 8. Predicted (A) without dark matter and observed (B) rotation curves for a typical spiral galaxy. Source Wikimedia Commons

More recently, measurements of gravitational lensing (the bending of light when passing near to very massive objects as predicted by General Relativity) of background objects by foreground galaxies is consistent with the presence of dark matter.

One observation is particularly compelling: the Bullet Cluster of galaxies consists of two clusters of galaxies that are part way through colliding. Gravitational lensing and conventional astronomy in the visible and X-ray spectra show that the dark matter and most of the ordinary matter in the form of hot gas have become separated in space. Hot gas within the clusters interacts electromagnetically as well as gravitationally and has been slowed down by the collision – dark matter is not affected electromagnetically and so the dark matter of the two clusters appears to have passed unaffected one through the other.

The CMB itself is affected by the presence of dark matter. The detailed models, which determine the evolution of the initial perturbations in the Universe, and which eventually give rise to the anisotropies in the CMB as well as the distribution of both ordinary and dark matter, are consistent with the Standard Model, including the theory of Baryon Acoustic Oscillations. The statistics of the CMB are consistent with the dark matter hypothesis.

Alternative explanations for the observations have been proposed, such as modifications to Newtonian gravity. Although some of these alternative hypotheses match some of the observations well, none is as consistent with the full range of observations as the Standard Model incorporating dark matter.

The particle that comprises dark matter has not been identified.

More proof of aether…

Some candidates have been eliminated by experiment, although there are many candidates for which there are yet to be tests. Many different sorts of observation provide evidence for the existence of some form of dark matter, but it is true to say that *physicists will not be entirely comfortable* on this score *until* either its constituent exotic particle is detected directly, or *physicists come up with some alternative physics that explains the observations at least as well as the current explanations.*

Already have…aether.

3.5 Dark energy

A supernova is the huge explosion of a star, which in some cases can briefly outshine the luminosity of an entire galaxy. Supernovae are thought to be caused by a number of different mechanisms that are classified by the spectral characteristics of the light emitted and by the details of the light curve (the light curve is how the intensity of light emitted by the supernova grows and fades over time). One particular sort of supernova, known as Type 1a[23], has extremely uniform characteristics – Type 1a supernovae all behave the same and so they are very useful as standard candles to measure distances in the Universe.

Two exciting and unexpected papers were published in 1998. Adam Riess et al[24] and Saul Perlmutter et al[25] investigated the distant Universe using Type 1a supernovae and discovered that the *expansion of the Universe is currently accelerating by comparing the brightness of these supernovae to their redshift. This was unexpected* –

Dark energy – another misnomer for aether..

that the Universe is expanding, but the cosmologists expected that the expansion would be slowing down under the gravitational influence of the matter in the Universe.

Furthermore, if the Universe is flat (i.e. the curvature of space-time is zero), the mass-energy density in the Universe must be a certain critical level. WMAP confirmed that the Universe geometry is flat or near to flat. The mass density of ordinary and dark matter is just 30% of the critical level according to observations on a large scale of the number density and mass of galaxies[26]. Further evidence for the existence of dark energy comes from the CMB itself[27].

If there is a kind of energy in the Universe accelerating the expansion, then the density of that energy must be added to the density of ordinary and dark matter in determining the total density of the universe. Therefore, cosmologists have proposed the existence of dark energy, which explains two observations:

1. *The total mass energy density of ordinary matter, dark matter and the proposed dark energy is close to the critical density which explains why the curvature of space-time is near or equal to zero*

   ST isn't curved…. It's Euclidean.
2. *The dark energy causes a pressure which explains the observed acceleration of the expansion of the Universe*.

   Aether effect…

The actual nature of dark energy is currently a mystery.

Most of MS is…

mThe FLRW solution to the Einstein field equations (see Section 3.2 above) has a term called a cosmological constant, which is represented by the Greek capital letter lambda (Λ) in the Friedmann solution. If the cosmological constant is non-zero then it could have a value that would explain the accelerating expansion and the critical density. Such a constant is allowed in GR and would be constant in time and space and could represent the energy of the vacuum. Other ideas include a scalar field called quintessence, which can vary in time and space. Current measurements of the Universe indicate that the density of dark energy does not change as the Universe expands, which is consistent with dark energy being a cosmological constant.

3.6 The ΛCDM model

So, taking all these interlocking observations into account, and many more that we don't have the space to explore, the current Standard Model of cosmology is the ΛCDM model, where Λ represents dark energy and CDM stands for Cold Dark Matter.

The ΛCDM model is based on the Big Bang with inflation and describes a homogeneous isotropic expanding Universe that has flat geometry and in which the expansion is currently accelerating.

It might seem strange that we are familiar with and have characterised in detail merely 5% of the matter and energy that makes up the Universe – some 25% in our best model is dark matter and 70% is dark energy, and frankly we don't know at the moment what dark matter and dark energy are. Some people, particularly those who have a bone to pick with modern science, criticise modern cosmology for "inventing" dark matter and dark energy. They use every trick of rhetoric to suggest that these concepts are arbitrary and ill-evidenced, and that modern cosmologists are either incompetent, engaged in a massive conspiracy or both.

A good strategy..reverse the reasoning .. Compare DM and DE to aether effects.

The fact is that physicists have not arrived at the ΛCDM model lightly. As we have seen, there are extremely good reasons for proposing the existence of the Big Bang, inflation, dark matter and dark energy. One of the key pieces of evidence is the *CMB itself. Its uniformity to one part in 100,000 supports the concept of a homogeneous and isotropic Universe*.

Research

ΛCDM has only six free parameters

Research….16??

and yet it predicts the details of the power spectrum of the CMB, to a quite remarkable precision out to l=10,000[28]. Further parameters can be derived from the best-fit six-parameter model, which are consistent with observations. As well as measurements of the CMB, there *are many independent observations of the Universe, such as large scale surveys of galaxies, gravitational lensing, measurements of the Hubble constant and so on, which either are direct evidence in support of the model or are consistent with it.*

Challenge galaxy surveys, lensing , hubble 'constant….

Although the Standard Model fits the observations very well, few, if any, physicists would claim that it is accurate in all respects. Nor is the scientific community complacent. A great deal of work is underway to refine the model and to resolve discrepancies. Collaborative physics projects are underway or planned to search for the origin and nature of dark matter – the need to understand its nature is widely acknowledged by the physics community. Theoreticians are considering and publishing alternative cosmological models that include ideas based on modified gravity, and potential departures from homogeneity and isotropy are under active consideration.

The New Geocentrists would have you believe that ΛCDM, indeed all of modern cosmology, is a theory in crisis and that the entire edifice is about to collapse, clearing a building site for a geocentric temple. The reality is different – *astronomical and astrophysical observations over the last two decades have* strengthened *the evidence for the Standard Model or something very like it.*

Challenge
There is no conspiracy of silence – anomalies and other pieces of evidence challenging the Standard Model, such as they are, are all detected, identified, published and discussed openly by the physics community
Cite counter proof….

without whom the new geocentrists would not be aware that the CMB exists, much less that there are unexplained anomalies associated with it. Is it possible that ΛCDM is entirely wrong and that cosmologists, astrophysicists and theoretical physicists have been barking up the wrong tree for decades? Of course it is possible. There is no absolute proof in science and it is possible that some future observation or combination of observations will force a reassessment of the fundamentals. However, given the complex interlocking empirical evidence it is *unlikely* that ΛCDM is entirely wrong; and even if it is, that doesn't imply that geocentrism or anything like it is correct. The fallacy of False Dichotomy, "you are wrong so I must be right", is one of which the geocentrists are frequently and unashamedly guilty. With that in mind, it's time now to look at the anomalies in the CMB that don't appear to fit the Standard Model.

4 Anomalies in the CMB

So, what are the anomalies in the CMB? The inflation-driven Big Bang ΛCDM model makes certain predictions about the statistics of the random fluctuations in the temperature of the CMB. We have seen that measurements show that those predictions are met to a remarkable degree – see Fig 7. Other predictions, such as the Gaussian distribution of temperature are also closely met[29]. Nevertheless, detailed analysis of the statistics and structure of the CMB anisotropy reveals features that are not predicted under the Standard Model and it is these anomalies that we are going to review now.

4.1 What are the anomalies?

The anomalies were hinted at by the COBE satellite data, but were first fully identified by WMAP and have since been confirmed by the Planck satellite. Let's look at the most important ones:

1. You will remember that the anisotropy power spectrum shows how much the temperature of the CMB varies as a function of the scale or angular size of the fluctuations (see Figs 6 and 7). Compared to the predictions of the model, the CMB anisotropy lacks power at the largest scales. The quadrupole (with four lobes, two hot and two cold) and to a lesser extent the octopole (with eight lobes) show less difference in temperature between hot and cold lobes than predicted[30].
2. According to the Standard Model, *the alignment between the lobes of various multipoles of the CMB anisotropy should be random. WMAP found a significant and anomalous alignment between quadrupole and octopole. Moreover these were*approximately *aligned with the autumnal equinox and the dipole*.
   Approximately = almost certainly !
   The equinoxes are two points on the celestial sphere where the plane passing through the Earth's equator and the plane of Earth's orbit round the Sun – the ecliptic plane – intersect. *The CMB dipole means that the CMB is hotter in one direction than the opposite direction by about one part in a thousand, which is conventionally explained by a Doppler shift of photon energies in the CMB caused by the motion of the solar system through the Universe with respect to the rest frame of the CMB[31]*.
   Relative Doppler shift

   Planck found the same alignments at a somewhat lower significance. See section 4.2 for a detailed description of these alignments, which are a major plank in the geocentrists' attack aimed at discrediting the Copernican and Cosmological Principles, and proving geocentrism.
3. *The Standard Model predicts* that not only should the temperature of the CMB be uniform wherever we look, which, as we have seen, it is to a remarkable degree, but that the *anisotropies should be the same wherever we look*.
   Andy Andromeda
4. The Planck CMB data confirms earlier measurements that indicate that there is more variation in the temperature in one hemisphere versus the opposing hemisphere[32], as well as other differences in the statistics in hemispheres divided by the galactic plane (the plane of the Milky Way galaxy)

and more significantly in hemispheres divided by the ecliptic plane (the plane of Earth's orbit round the Sun).

5. The data shows that there is *a significant degree of anisotropy power asymmetry*, …. which varies by direction depending on the scale of the anisotropies[33]. In other words there is more temperature variation in one part of the sky than another and the direction of the greatest variation is different for different scales. The amount of this asymmetry is not greater than predicted by the theory, but there is *significant clustering of the direction of the asymmetry around a preferred direction that is anomalous.*

research

6. Planck confirms earlier findings that odd multipoles have somewhat high power compared to even multipoles[34]
7. There is a statistically anomalous Cold Spot in the CMB sky[35]. The Cold Spot subtends about 5° on the sky. It has been extensively studied[36] and physicists have made various suggestions for its cause.

4.2 The Anomalous Alignments

We expect the spherical harmonics to be off-center…

Since the geocentrists focus particularly on the CMB alignments that are not predicted by the Standard Model, let's take a deeper look at these in preparation for a fuller discussion of their claims.

The alignment between the CMB dipole and the equinox has been known for over 30 years.

Plenty of time for resolution….but none so far…

The magnitude and direction of the dipole have been refined by many probes of the CMB including the satellites COBE, WMAP and Planck. The measured values for the direction and amplitude of the CMB dipole have remained the same for a decade or more.

The direction of the CMB dipole vector is 14.1° from the autumnal equinox (The way the geocentrists describe these alignments you'd think *that they are exact). No sensible person suggests that this alignment on its own is remarkable.*

The statistical result can be stated as the mean , or by including the std deviation , mean +/_ std dev. The mean is chosen here , and then the lack of an error is inferred that the geos claim no error?

Straw man Challenge: Exactly where did the geos claim zero error in the CMB alignment data?

Not only are the quadrupole and octopole approximately aligned to one another but they are also approximately aligned with the equinox and the dipole. 9-year WMAP data showed a highly significant alignment of just 3° between quadrupole and octopole[37]. The more precise Planck satellite data found a less exact alignment – between 9° and 12.3° which reduces to 7.6° to 8.3° when certain contributions to the quadrupole from the solar system velocity with respect to the CMB rest frame are subtracted. The significance of the alignment of quadrupole and octopole lies between 97% and 99% (in other words there is only a 1% to 3% chance that it occurs by chance).
Using the data from Table 18 of ref [29], which shows the direction in galactic co-ordinates of quadrupole and octopole as measured by Planck for a number of different component separation schemes (which are algorithms used to clean the CMB maps of foreground contamination, which is microwave energy that arises from sources that are not part of the CMB*), I have calculated the measured angles between various features.*

Check calc of angle in gal coors..

The angles between quadrupole, octopole, dipole, equinox and ecliptic plane for the KQ corrected SMICA component separation scheme are:

1. *The quadrupole to the equinox is* ***23.1°***
   Which equinox – vernal or autumnal?
   And which 4-pole plane… there are 4 of them ..
   Very shabby…

2. The octopole to the equinox is **17.6°**
   And which 8-pole plane… there are 56 of them ..

3. The quadrupole to the dipole is **28.5°**
   4
4. The quadrupole to the octopole is **7.7°**
   4 x 56
5. The dipole to the equinox is well known and is **14.1°**
   2
6. The dipole to the ecliptic plane is **11.1°**
   1
7. The quadrupole to the ecliptic plane is **16.0°**
   4
8. The octopole to the ecliptic plane is **8.6°**
   56

A list of deceptions…
Total possible alignments …. 351
Measured by alec…..8 <3% studied out of all alignments.

The real surprise consist in the alignments within the 4-and 8-pole …the astonishing coplanarity of the 4 quadrupole planes and the 56 octopole planes

So the alignment of these CMB features with themselves, with the kinematic dipole caused by the motion of the solar system, and with the equinox, is far from exact and lies within a 30° cone.

Amazing… what reason could possibly be given to treat each mean alignment (with its woefully incomplete data and unstated error bars) by finding its rms value?

The probability of all these alignments is the PRODUCT of their individual probabilities..of each being aligned in 3 Dim space.

Nevertheless this alignment of a number of nominally independent directions is unexpected and *the probability that all four align to this degree randomly is only about 0.3%.*

Recompute this

The consensus is that alignment of the equinox, dipole, quadrupole and octopole at about a 3σ level is significantly present in the data (i.e. only 0.3% probability that they all occur by chance). The probability that any two align systematically given that the other two align with them and with each other by chance is much higher, of course, at between 2.5% and 5% as Copi et al have shown in their review of the low multipole alignments as measured by Years 7 and 9 data from WMAP and Year 1 data from Planck[38]. They demonstrate that *the alignments of the quadrupole and octopole are significant* at the levels we have discussed, but that *their alignment with the dipole may well be a statistical accident.*

Examine the reasoning for this statement… [38]

They assess the alignment of the quadrupole and octopole with respect to the ecliptic rather than the equinox itself, and conclude that although solar neighbourhood explanations for the alignment are plausible, no specific explanation of this kind has been found. They state:

"*The statistics offer only weak, and even confusing, guidance as to what is correlation and what, if anything, is causation. …*

Stats only give math. correlation …not the physical interpretation of etiology renedered by the rational mind.

Unfortunately, the fact that the dipole direction simply happens to be just off the Ecliptic plane, which passes about 30 degrees from the Galactic poles, makes establishing the priority of one correlation over another difficult just on the basis of statistics of CMB temperature data. Some, or all, of these correlations are presumably accidental"

Presumably is the key word. An obvious intrusion of MS metaphysics… a cryptic ideology that assumes the high pattern of correlations of npoles with terrestrial sky directions is

accidental….according to their world-view = mind-set = interpretation bias!

They conclude:

"*We think it is preferable to acknowledge that the existence of anomalies seen in the WMAP and Planck maps at large angular scales may point to residual contamination in the data or to interesting new fundamental physics*."

Again…we prefer…

The data for MW 'contamination' has been filtered several ways by many CMB researchers .

No contamination claim is made when CMB data agrees with LCDM!

There is interesting new fundamental physics here… it's the strong evidence of GC ,

Which the MS teams are rather not interested in…

A contrary view was expressed by Bennett et al in one of the papers published by the WMAP team[39]. They suggest that the significance of the anomalies as cosmic phenomena is less than is widely claimed in the literature, owing to the influence of what is called *a posteriori* choice of statistics. In other words in a complex data set (and the CMB data set is very complex), there are bound to be some coincidences and *we are focusing on the anomalies we have found, to the exclusion of the vast quantity of non-anomalous data*.

OK then …what are the *non-anomalous data*.in the first 3 n-poles?

Some anomalies are expected to exist in any complex dataset purely statistically. It is worth quoting extensively from the abstract:

"*A simple six-parameter ΛCDM model provides a successful fit to WMAP data… While there is widespread agreement as to the overall success of the six-parameter ΛCDM model, various "anomalies" have been reported relative to that model… In most cases we find that claimed anomalies depend on posterior selection of some aspect or subset of the data… We conclude that there is no compelling evidence for deviations from the*

ΛCDM model, which is generally an acceptable statistical fit to WMAP and other cosmological data."

BIG difference… the 6 LCDM 'adjustable constants'! were determined post facto by curve fitting… they were chosen as the best fit to the CMB data. They force the data to fit the model in a 6D modeling space.

Conversely …. The multipole alignments with Earth come directly from the raw data…. With no imposition of an proposed external model.. certainly not by any of the CMB Analysts! There is no curve fitting …. The data declares the pattern ..to all who are not blind to see it.

Equating the CMB npole patterns with the kludged LCdM is a transparent mendacity.

The CMB alignments

See also [40] for an earlier paper by Copi et al published at about the same time, where they argue that the anomalies are present and significant. Since Bennett et al reported in 2010, the Planck team have published the data that we discussed above. The *consensus of the scientific community now is to adopt the working assumption that the anomalies are statistically significant and are not merely accidents that have been made prominent by an* a posteriori *choice of statistics*.

We might call this the acceptance of overwhelming evidence… despite desperate efforts to ignore or explain it away..

The consensus position is to accept that the ΛCDM model is the best fit to the known data, but that *the anomalies might be signals for new physics that would lead to some modification or refinement of the model.*

Let's not try to downplay the alignments…along with other cosmic patterns this represents a complete paradigm shift in cosmology requiring a major re-think of all theories in physics dependent on the CP….a return to pre-Galilean thinking.

It seems to me that this is a prudent approach, which avoids the pitfall of potentially missing some important new physics. *There is nothing to lose by tentatively treating the anomalies as significant, but potentially much to lose by treating them as statistical flukes.*

Agreed…. But what sort of 'treatment' is intended?

4.3 Potential Explanations for the Anomalies

There have been a substantial number of ideas advanced to explain the anomalies:

1. An artefact of our focus on anomalies and the *a posteriori* choice of statistics as described in the previous section
2. *Instrument systematics: there is a possibility that something in the design or operation of the satellite radiometers gives rise to data artefacts that cause the apparent alignment*. *This is extremely unlikely now that Planck, which uses a very different instrument design from WMAP, finds the same anomalies albeit with somewhat reduced significance.*

   There have now been 3 CMB sky surveys….. It's about time to accept uncomfortable facts …if , that is, the interpretation is to be fair and unbiased…
3. Data analysis systematics: this covers a wide range of possible errors – the data analysis includes the various filters applied to reconstruct the data, the cleaning of the raw data to remove foreground, and to correct for systematic late time effects on the primordial CMB such as *the Integrated Sachs-Wolfe effect and gravitational lensing, which can lead to the sort of anomalies we see.*

   Really?…an assertion with no evidence or analysis..
4. It is fair to say that *people have looked hard for systematic data analysis artefacts to explain the anomalies and have failed to find them and, again, since different experimental designs find the same anomalies, it seems unlikely that the explanation will be found here*

   Then let's stipulate to that effect …. So much time has been wasted on this wild goose chase…

   (although Copi cautions that the First Year Planck data calibrates against the WMAP dipole)
5. Foreground contamination: in attempting to measure the CMB, there is a possibility of foreground sources of microwaves contaminating the data. Such sources can lie within the solar system, or be galactic or extra-galactic. A considerable amount of foreground contamination is removed in reconstructing the cleaned full sky CMB maps. The foreground contamination includes point sources (i.e. astronomical objects such as stars and galaxies), synchrotron emission, thermal Bremsstrahlung, thermal dust emission, and so on. (We don't need detailed descriptions of these potential sources of foreground – we just need to know that these are all physical processes that can contaminate the

measurement of the primordial radiation*.) It is possible that the anomalies are due to imperfect cleaning of foreground contamination, but that is less likely now since the Planck publications find the same anomalies, in spite of the fact that Planck and WMAP use different component separation algorithms (and Planck actually makes use of four different algorithms).*

Then let's stipulate to that effect …. So much time has been wasted on this wild goose chase…

However, foreground contamination as a source of at least some of the anomalies remains a possibility

..Always an escape clause…..

6. Secondary or late-time anisotropies: the CMB light is known to be affected by its 13.8 billion year passage through the Universe by a number of effects, which include scattering from electrons, gravitational lensing and gravitational red-shift. These effects tell us a great deal about the Universe, but must be corrected for in order to get the statistics of the CMB anisotropies as they were at the time of decoupling. *It is possible that some as yet unidentified but systematic late-time anisotropies remain in the cleaned data that can explain the anomalies, but there is currently no compelling suggestion for what they might be.*

   More possibilities that really aren't.

7. New physics. *It is possible that the anomalies arise from real processes in the Universe, which cause some departure from strict homogeneity and isotropy on a large scale. Amongst other explanations, astrophysicists and theoretical physicists are investigating potential sources of anisotropy in the early Universe that are not currently part of the Standard Model, such as primordial texture and topological defects. Some metrics that are not flat, isotropic and homogeneous, when overlaid on the FLRW metric, explain the alignments to some degree[41]. It is possible that primordial magnetic fields on the scale of the current horizon can give rise to a preferred angular direction in the CMB. It is also possible that the departure from strict anisotropy indicated by the alignments can be accommodated by the Standard Model as a very large scale primordial anisotropy falling within the observable horizon[42]. So far, although there have been many physical explanations proposed for the alignments, no one appears more compelling than others*.

Even more possibilities that really aren't.
The Planck team has so far not released any CMB polarisation data, which is due in late 2014. The correlation or lack of it, between temperature and polarisation anisotropies can constrain explanations and help in the search for a cause and so *the Planck polarisation data is eagerly awaited.*

Update current research…

To summarise: the CMB data from WMAP and Planck is fully consistent with the standard six parameter Big Bang inflationary ΛCDM model. However there are anomalies in the tiny ripples of the CMB that are not predicted by the Standard Model and there is, as yet, no compelling explanation for the cause of these anomalies.

4.4 *So, is the Universe inhomogeneous and anisotropic?*
Of course it is.

With such compelling evidence presented in these 4 words…why even discuss it further?

It is obvious that the Universe is both anisotropic and inhomogeneous on the scale of galaxies. A galaxy is, by its very nature, a gravitationally bound set of stars (and dark matter), which has a greater mass/energy density than the space between galaxies. In fact, *it is clear, if one considers the distribution of galaxies from large galaxy surveys such as the Sloan Digital Sky Survey, that the Universe is inhomogeneous at least up to the scale of galaxy clusters and super clusters.*

The SDSS did find symmetries among the inhomogeneities… spherical symmetries… with Earth at the center…

Surely we will be discussing those…

Indeed it is inhomogeneous on the scale of the cosmic voids, sheets and filaments, which is known as the Cosmic Web, and which have structures at least 350 million light years across. According to the Standard Model, this structure arises from the same fluctuations that give rise to the anisotropies in the CMB.

So what do we mean by the Cosmological Principle's tenet that the Universe is isotropic and homogeneous, if it is obviously not so up to scales of 350 million light years?
To me, it means the CP has lost its principles.

The Cosmological Principle refers to the average distribution of matter and energy on the very largest scales that is used to make predictions about the long term behaviour of the Universe. The point is that *the standard ΛCDM model already allows for inhomogeneities and anisotropies in the Universe,*
..then it is not compliant with the CP, is it?
so *it is only on scales beyond the transition to homogeneity at about 350 million light years[43] that the Cosmological Principle and the FLRW metric fully applies –*
So observations have been made beyond 350 megaLY that confirm homogeneity ..?

Check [43] for exact statement and analysis

otherwise it is an approximate description with perturbations due to the inhomogeneities of matter condensed into stars, galaxies and galaxy clusters.

5 The New Geocentrists' claims

Bob Sungenis and Rick DeLano, with support from minor figures in the geocentricity movement such as Robert Bennett, Mark Wyatt and James Phillips, claim that the scientific observations that we have been discussing falsify the Copernican Principle, demolish modern cosmology and prove geocentrism.

I can do no better to convey what they say and how they say it than to let them speak for themselves:

- *Everything we think we know about our Universe is wrong* – Trailer for *The Principle Movie*
- *What did COBE, WMAP and now Planck show us? Astounding as it may seem, the data reveals the Universe is non-Copernican, that is, it is not homogeneous as predicted by the Big Bang. There are warm and cool spots all over the Universe, which means the Universe is defined, with special locations and directions.*
- *They showed us that if we draw lines that connect all these warm and cold spots …those lines would point like an arrow from the edge of the Universe directly to the Earth*
- *The warm and cool spots of the CMB are systematically organized into distinct regions of the Universe that, when graphed on an X and Y axis, point directly to the Earth as the center of the distribution… It is very special and was placed in a very unique place in the Universe – in the very center.*
- *…the Big Bang – that is on the operating table taking its last breaths before it dies. And the Planck probe just put the knife into its heart*
- *So, even after they added in the fudge factors of Inflation, Dark Matter and Dark Energy for 96% of the Universe, the Planck probe comes back and says, "Sorry, the data from the Universe doesn't fit your model. Go back to the drawing board and try again."*
- *You know the old saying, "three strikes and you're out." Well, that is the case with Krauss and the rest of the scientific world. They have no place else to go.*-Sungenis[44]
- *…the CMB shows that the whole Universe is centered on the Earth.* – Sungenis[45]
- *It was so puzzling that NASA sent up the COBE probe in 1990 to take more measurements of the CMB. Lo and behold, COBE reported that the CMB was aligned with the Earth and the Sun. They couldn't believe their eyes. So they sent up another probe in 2001 called the Wilkinson Microwave Anisotropy Probe (WMAP). You guessed it. WMAP came back with the same data – the Earth and Sun were aligned with the entire known Universe. -* Sungenis[46] [47]
- *The most shocking image I have ever seen, of Earth in the center of the Universe, is found on page 9 of the below new paper by Rubart and Schwarz* – DeLano [48]

- *Newest Evidence Shows Earth At the Center of the Observable Universe* – DeLano[49]
- *The Universe's largest visible structure is aligned in completely inexplicable ways with supposedly insignificant Earth. This is now established, scientific, observational fact.*- DeLano
- *At the same time the alignment (aka: "axis of evil") is an incredibly strong and compelling piece of evidence pointing to a geocentric universe! –* Phillips[50]
- *With COBE we saw that the CMB was aligned to the earth's equinox and ecliptic, but science said bah, not possible. So we sent out the WMAP. The WMAP more clearly showed that the CMB is aligned to the earth's equinox and ecliptic, but science said, bah, bah (and inside oh crud). So we sent out the Planck, using a different sensor and scanning methodology. Well Planck has once again verified that the supposed most primal signal in the Universe knows about is pointing directly at the earth.*- Wyatt[51]
- *Doesn't anyone realize that the universal Cosmic Microwave Background has local axial and planar symmetries only when viewed from Earth? Doesn't any scientist on this planet realize that it isn't a planet? When will our stiff-necked scientists bow their heads and acknowledge the elephant in the living room, the emperor with no clothes?* – Bennett[52]

That's more than enough to give you a flavour for the lurid rhetoric and the reckless content of the geocentrists' arguments. In many cases, they also reveal *a fundamental misunderstanding of the science or the methods, which are too tedious to address individually.*

C'mon..give us a few examples…even though tedious we found a lot of your misunderstandings

Contrast the tone of their writing with the obsessively detailed and careful discussion that can be found in any of the scientific papers referenced in this article.

Is truth measured by the description volume? A relevant test and reasoning upon it can usually destroy the effusive sci-babble found in the sci journals.

5.1 Geocentrists' misunderstanding

The geocentrists are clearly wedded to an a priori *position, which is that the earth is the unmoving, non-rotating centre of the Universe. That is non-negotiable for them and they exploit any argument that they believe remotely supports their case.*

They play down all others. That's not the way proper scientific discourse works. Rather than following the evidence where it leads, they are determined to wrestle the evidence into a shape that appears to support them. Reading the quotes above, one is struck by their categorical assertions and the extreme language in which they express them. Do the findings warrant their conclusions? Do they actually understand the scientific observations or are they relying on some cartoon version of them that they misinterpret in their favour?

A personal note: It may shock Alec that I was wedded to the acentric position of relativity until 10 years ago …that's all I had ever been taught/brainwashed. My Ph.D. thesis was in fact on GR. Application of philo-realism and the sci meth led to a paradigm shift ..one that has been even more wedded to my world view than the prior one. Evidence – like the CMB patterns – keeps pouring in and reinforcing the GC model.

Had Alec interviewed me or the others, he would have found a similar conversion ..when exposed to all relevant information filtered out by academia.

Does Alec listen to our arguments or is he as blind to rational discussion as he claims us to be?

Let's look at the geocentrists' position regarding their private story about cosmology and the CMB measurements (and really about Enlightenment science in general). For them, *cosmology (indeed all of physics from Copernicus onwards) is a huge modernist conspiracy to displace the Earth in the minds of the public from what they see as its rightful place in the centre of the cosmos*.

Conspiracy:

1)secret plan by a group to do something unlawful or harmful.

2) the action of plotting or conspiring.
Like the MSP, we have come to a common belief that draws us together.
Like the MSP, we associate to promote our common belief… like political parties… like any social group.

Conspiracy overstates what is at best a 'birds of a feather…wink and nod' agreement, that is not a plot in the pejorative sense that conspiracy infers, as much applicable to GC as MS.

They believe that "inconvenient" discoveries are swept under the carpet to maintain the conspiracy of silence that the science community has erected, and that in their movie, they are tearing down this veil for everyone's benefit. *As far as they are concerned, science in general and physics in particular is an atheistic plot to undermine Man's special place in the universe.*
I will admit that there is a plot to promote atheism via MS science and physics…. A diabolical conspiracy.

Well, if the disciplines of cosmology and physics are conspiring with atheists in this way, it must be the most incompetent and impotent conspiracy of all time. *What sort of conspirators rush to publish "inconvenient" findings as soon as they are discovered for the conspiracy?*
Rush to publish 'inconvenient 'findings ??   counter –examples??
The geocentric crew would have no idea that the CMB has anisotropies and that some of those anisotropies are anomalous if it were not for the scientific publications of the very same people they regard as conspirators.

Would they rushed to publish if they had known the implications of the data? I have published a model(ALFA) that refutes relativity – both flavors – and supports the GS world-view.
Who's rushing to openly discuss the implications? None.

For heaven's sake, they wouldn't even be aware of the existence *of the CMB without them.*

And probably some CMB researchers wish they hadn' found the CMB and its off-paradigm patterns.

A further problem for geocentrists is that they understand neither the way physics as a discipline works nor the details of the physics they try to discuss. For example, Sungenis lambasts cosmologists for modifying the Big Bang model by introducing inflation, dark matter and dark energy [44] [45] but fails to acknowledge that modifying the hypothesis to take account of new observations is *how science works*. People don't propose overarching scientific theories out of the blue that are absolutely correct in every tiny detail like some vast infallible revelation. *Our understanding of the Universe is gradually improved, step by step by a few clever ideas, a vast quantity of hard labour and false starts, dead ends, and breakthroughs.*

Refuted by the paradigm shift analysis of sci history… see

The Structure of Scientific Revolutions by Thomas S. Kuhn

Physics and cosmology is a work in progress, and the fact that the Standard Model has evolved over time to accommodate new observations is a crucial strength – going where the evidence leads is what makes science the best way that we know to understand the natural world.

As for the geocentrists not understanding the science itself, two examples will suffice. Sungenis writes: *"…how does Big Bang cosmology then explain the quadrupole/octupole axis, which is perpendicular to the dipole axis? It cannot be created by a movement of the sun-earth system through the CMB since, obviously, the sun-earth system cannot be going in one direction to create the dipole and, at the same time, going in an orthogonal direction to create the quadrupole and octupole. Something is definitely amiss here."* [53]

What's amiss is Sungenis's understanding of the CMB anisotropies – no knowledgeable person suggests that the quadrupole, octopole and higher multipoles arise primarily from motion of the solar system. As we have seen in Sec 2.4, they are the decomposition into spherical harmonics of the CMB anisotropies caused by Gaussian, nearly scale invariant fluctuations in the early Universe. By pointing out this misunderstanding I am not picking nits but pointing to a basic foundational lack of understanding on Sungenis's part.

DeLano writes in [48], *"The most shocking image I have ever seen, of Earth in the center of the Universe, is found on page 9 of the below new paper by Rubart and Schwarz".* That paper is reference [76] of this article. The only image to be found on page 9 of that paper does not merit hyperbole of that order and it obviously doesn't show what DeLano thinks it shows. See Fig 9.

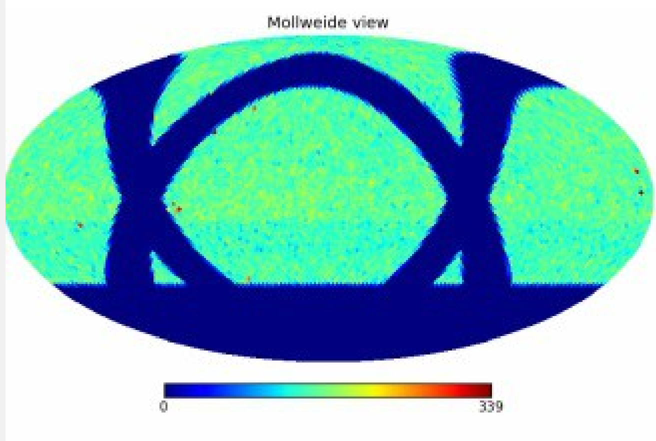

Fig 9: The most shocking image Rick DeLano has ever seen; from page 9 of ref [76]. The diagram shows number counts of radio galaxy sources from NVSS in equatorial co-ordinates. The dark blue solid lines are areas where there is no data or data has been masked out to prevent contamination from the Milky Way galaxy. Source: Rubart & Schwartz76

The science of the CMB is complex as we have seen, and we have barely scratched the surface of the subject. *What hope do the geocentrists have to understand it and to draw reasoned conclusions from the measurements, devoid as they are of scientific training and mathematical skills?*

As to realism and the sci method, Alec what is your training and skills?

The geocentrists' key misunderstanding of the science, which is the foundation for their most vociferous claims, is their misinterpretation of the directional alignment of the multipoles as data which yields positional information. The alignments, anomalous as they are, carry no information about the location of the Earth or any other object.

If this is the key objection , then it is also the key error in the AMc argument.

Note: the BB center of expansion is the center of spherical symmetry…13.8 gigaLY from the Earth.

1-Model a 2D line with best fit..

2- model a 2D circle with best fit..   cylindrical CS

3- model an off center circle with cyl CS

Extend to 3D CMB.

We'll explore this point in more detail below.

5.2 Are the geocentrists' claims warranted?

In a sense this is the core of this article and what comes before serves as a preamble to prepare readers for this part of the discussion. The fact that there are unexplained anomalies in the CMB is undeniable and no-one is seeking to deny it. But the key question is whether these anomalies warrant the rhetoric and extreme claims of the geocentrists. There are four classes of argument used by them that we will consider in turn.

5.2.1: Geocentrist argument #1: "The CMB alignments point straight at the earth and therefore the earth is at the centre of the Universe."

Although the approximate alignments of the dipole, quadrupole, octopole and ecliptic/equinox are not predicted and are currently unexplained, *they do not "point like an arrow directly at the earth" and they are not evidence for geocentrism*.

Dipole by itself does…

As we have seen, the alignment is far from exact – the quadrupole vector is 23.1° from the equinox and 16° from the ecliptic plane, and the dipole is

28.5° from the quadrupole (Planck data, SMICA component separation, *kinetic quadrupole corrected*).
Assumes 4-pole is due to motion…DENIED!

Moreover, *the geocentrists have never explained in detail how this* approximate *alignment of the low multipoles of the CMB with the ecliptic and the equinox is evidence for the earth being at the exact centre of the Universe.*
Should be off-center by 900 km (COBE) or 1,500,000 km(WMAP-Planck)

It is clear that the geocentrists rely on a caricature of the science to make their claims. Sungenis misinterprets the approximate alignment as an arrow (or a sword in another case) pointing straight at the Earth. Wyatt claims that "*the supposed most primal signal in the Universe knows about is pointing directly at the earth*" (sic). DeLano writes "*The Universe's largest visible structure is aligned in completely inexplicable ways with supposedly insignificant Earth*".
In all of these quotes, the geocentrists interpret the vectors that define the orientation of the multipoles to be carrying positional information. In other words, they imagine that the multipole vectors are lines which pass through the Earth, and coincide at the Earth in a unique manner.
Assumption is that the spherical harmonics are centered on the receiving antennae ….not on the earth frame, but off- center by the COBE and L2 distances.
Distances are measured in SH coordinates form the antennae location.

They imagine that there is no other planet or star or other body in the Universe where the vectors coincide,
SH give a unique set of multipole coefficients for a given data set…
Alec is invited to prove otherwise..

and that therefore they uniquely point to the Earth's location. However, their understanding of the vectors is simply wrong. *The vectors define directions but carry no information about location.*
.the center of the SH expansion and the multipole directions has been defined….. The MP vector coefficient measures the intensity/temp of the CMB radiation in that direction.
By moving the center to other locations the effect of the npoles can be predicted.
See the off-center models singal etal…for more evidence…
Black-body location….
Monopole can't be determined by differential data…

They are not unique lines on which the Earth is located. They don't point *to* any location.
To illustrate this*, let's think about a crystal, which is a structure that has a number of well-defined planes.*
Poor example (deliberately misleading?) the symmetry of a crystal matrix is Cartesian ; it has no topological origin….. no point , line or plane that is not repeated in the matrix (excluding edge effects).
The BB shell of expansion has an obvious unique point - the center.
A SH expansion of a crystal would repeat when shifted by the crystal spacing.

For example, rock salt has cubic crystals[54]. The planes of a crystal structure are analogous to the CMB multipole planes and the directions orthogonal to those planes are analogous to the multipole vectors. Imagine being somewhere in a vast salt crystal. You would be able to measure the orientation of the crystal planes (and they would be the same wherever in the crystal you were), and define those orientations by vectors orthogonal to the planes but the directions in which the vectors point would give no positional information. *They cannot be used to define a location in the crystal or to navigate to a specific location.*
Answered above…

Similarly, the CMB multipole vectors give directional information but no positional information. *If you were an astronomical distance away from the*

Earth, you would not be able to use the CMB multipole vectors to navigate to it.
The issue is: Do the npoles tell us if we are at the center? The dipole and any one of the other pole vectors tells us that we are within the error range

The center is located by the intersection of the dipole line and the 4- and 8-pole vectors
What's more, most of the planets in our solar system have orbital planes that align with the quadrupole and octopole to much the same degree that the Earth does. In fact, *because the alignment of the multipoles with the ecliptic is only approximate,*
Anything not exact is approximate….. vague…

the evidence strongly indicates that there is a vast number of planets in our galaxy (as well as an unimaginably large number in other galaxies) that have orbits that align more *precisely with the quadrupole and octopole than the Earth does*.
What evidence? Did you run a CMB survey from these vast planets…?.
Show us the data! Sci meth testability alert!
The anomalous CMB alignments simply do not distinguish the Earth in the way the geocentrists imagine that they do, and they certainly don't point to it as being in any way central.

Let's think about this in another way. Let's consider the nature of the CMB anisotropies. As we have seen, *they arise from density fluctuations in the early universe that are seeds for the current structure of galaxies and galaxy clusters.*

'we' have not seen this at all…. Nothing before 5000 years ago has been documented by human observers…. Sci meth testability alert!

If the alignment of the low multipoles is "pointing straight at the earth", then we would expect the quadrupole and octopole to be aligned at the earth and for that alignment to reduce rapidly as we move away from the

Earth. If they don't behave like this then they cannot distinguish the Earth's location

Come back to this. The npole values are fixed , representing temp asymmetries, not distance from the center.. Where do these wild ideas come from?

. *But the co-moving size of the structure that gave rise to the octopole is 29 billion light years across*,

An assumption that is refuted by the data …the origin of the 'structure' would be 13.8 gigaLY from the Earth…

and *the quadrupole is bigger than that*,

bigger than what…the diameter of the universe?? The npoles don't translate directly into distances…only by observation of the CMB sky at two or more locations..

so the alignment is the same a very long distance away from the Earth; in fact a very long distance away from our galaxy group.

As our English soccer coach would say….rubbish! This statement is so twisted, it's impossible to unravel.

There would be no way of distinguishing the location of the Earth from elsewhere in the Universe by measuring the direction of the CMB vectors. The idea that the alignment is a signal pointing at the Earth is based on a misunderstanding of the nature of the primordial CMB anisotropies. That misunderstanding is profound, but it is not one that the geocentrists are likely to correct quickly because they have invested a great deal of their rhetoric in it.

Neither Sungenis nor any of his colleagues can explain in detail just how the observations, including the alignments, support geocentrism.

List supporting results :

Let's assume that the alignment of the low multipoles with the ecliptic is caused by some as yet undiscovered physical effect, either local or cosmological as the geocentrists prefer – let them give us an example of what they think that effect might be, and how it causes the alignment of the low multipoles consistent with everything else that we know about the Universe, explaining in detail how the effect, *to the approximate degree that is measured*, leads to the conclusion of geocentrism.
Right back at you, Alec…
… Give us an example of what you think causes gravity, and how it causes inverse square attraction without a medium(MS dogma), consistent with everything else that we know about the Universe, explaining in detail how that cause , *to the approximate degree that is measured*, leads to the conclusion of gravitation.
Btw: theories based on general covariance have already been falsified…
The point is: we don't need to know the cause of the alignments to know that their very existence rules out the standard LCDM(if that's still the approved model).

Without hand-waving or table thumping *can they tell us precisely how this alignment is evidence that the earth is unmoving in the centre of the Universe? Of course they can't.*
Straw man alert… the CMB alignments DO NOT TELL US the Earth is at rest. They do tell us that the CMB radiation is symmetrically focused very close to Earth, with multipole alignments very close to visible solar system patterns like the ecliptic and equinoxes whereas the BB expansion models say the CMB origin is 13.8 gigaLY from Earth…..
This is consistent with a geocentric universe and not with a BB expansion model.

In order to do that, they must wind back to first principles by defining the origin and nature of the CMB in a way that is consistent with detailed measurements such as the anisotropy power spectrum of Figure 7. If you look at any scientific paper referenced in this article (references are generally to the arXiv pre-print server, which is open to all – unlike some other areas of science, this “conspiracy of cosmology” puts all its papers in free public view and not behind a pay-wall), *you will find that astrophysicists and cosmologists engage in discussion that is detailed and quantified almost to the point of obsession.*

Why visit the Against The Mainstream section of Cosmoquest…

http://cosmoquest.org/forum/forumdisplay.php?17-Against-the-Mainstream

After presenting your theory you are not allowed to ask questions, only to answer them. Failure to answer correctly or timely will cause stern warnings and eventual banishment… a typical example of liberal MS censorship and suppression of opposing theories by imposed monologue.

The challenge to the geocentrists is to stop leaping to conclusions and to *explain in detail what the source of the CMB is in their cosmological model[55],*

The source of the CMB aether winds is deep space (like the MS cosmic rays and GRBs) in the Leo half of the celestial sphere.

what physical effects lead to the approximate alignments we observe,

The alignments of the npoles are the equinox and ecliptic.
The equinox is the boundary where the annual seasonal wind reverses over the equator
The ecliptic is the plane in which the non- Earth solar system objects are carried …the motions include the reverse rotation of the Sun and Moon against the stellar rotation, the vortex winds moving the planets and secondary winds moving their satellites.

how those effects and those alignments provide positional information and evidence for geocentrism.

The aether winds are focused on the Earth …which is what geocentrism means.

It is worth noting that geocentrists are exercised by their tenet that the centre of the universe is *precisely* at the Earth. Both WMAP and Planck, which made the CMB measurements, were located at the Sun-Earth Lagrange point, L2, almost a million miles from the Earth*. In their model does that mean that the centre of the Universe is at the Sun-Earth L2, a million miles from the Earth?*

Of course not…. The off-center location of the CMB detectors contributes to the 'errors' in knowing the exact focus.

5.2.2 Geocentrist argument #2: "The CMB alignments point straight at the earth and therefore the Earth is in a privileged or unique place."

This is a similar (but less extreme) claim to #1. Similar arguments apply – to be credible, the geocentrists should identify the source and nature of the CMB, identify the effect that is causing the alignment and explain how the operation of that process and the actual measured data leads us to conclude that the Earth is in a privileged or unique place.

As we have seen, the alignment of low multipoles changes extremely slowly with distance away from our galaxy

***W*e have seen nothing of the sort…. What satellite measured the CMB while receding from the galaxy?**

because of the size of the structures that give rise to them (remember that the octopole has only eight lobes and the quadrupole just four lobes on the entire sky) – the low multipoles represent vast structures in the present universe. So *the CMB alignments would be the same not just at the Earth, but anywhere within a few billion light years of the Earth. They give directional but not positional information.*

The directions point to near Earth as measured near the Earth. Extending the directions into space has no effect on the value of the CMB temp received in that direction.

5.2.3 Geocentrist argument #3: "There are anomalies in the CMB anisotropy, and therefore the Cosmological Principle is false, therefore the Copernican Principle is false (therefore the Earth is *at a privileged place)."*
Let us remind ourselves that the CMB is uniform to ten parts in a million, and *that the CMB anisotropies arising from the Gaussian, nearly scale invariant fluctuations that eventually led, through the evolution of structure in the Universe, to the galaxy and galaxy group structure that we currently observe, were predicted long before they were actually measured*[56] [57].
A wild assertion, indeed… the CMB alignments are one of the many CMB anisotropies..they were not predicted by anyone, anywhere… as testified to by the shock(Axis of Evil) when they were discovered 25 years ago.

The anomalies in the CMB anisotropy, and other measurements that indicate some large scale anisotropy in the Universe (we'll look at some of these more closely in Section 6 below), such as they are, can be regarded as perturbations on a broadly homogeneous and isotropic Universe. So far *no anisotropies or inhomogeneities have been uncovered that are of a magnitude that preclude them arising from physical processes in the early Universe*.
But we are precluded from using tests today to claim knowledge of past processes…by sci method testability rule.

In addition to the uniformity of the CMB*, large scale galaxy counts indicate that the Universe is largely homogeneous above the 350 million light year scale*[43]*.*
The conclusion of [43] is rejected because it bases distance on the Hubble variable.
Hubble's 'law' has several possible causes besides the Doppler shift. Add refs….   Plasma redshift, aether density variation(dark matter), aether motion(dark energy).

Measurement of the average bulk flow of galaxies against the CMB rest frame, using data from the Planck satellite, indicates that there is no average flow, which is strong evidence for homogeneity on the scale of billions of light years[58].

The CMB anisotropies are predicted in detail by the inflation ΛCDM model and that model predicts structure on very large scales

Not if you read the latest papers…the CMB anomalies are in conflict with inflation theories… we note no refs for this claim contrary to current research.

– in fact the quadrupole, octopole and some cosmic portion of the dipole are the signal for this large scale structure on the surface of last scattering. *The structure is present everywhere in the Universe including within the observable part of the Universe in which we live.*

… the alignments have only been tested one place in the universe ….Another untestable imperative…yawn.

Therefore *it is possible that, on the largest scale, we live in an over or under-density* that arises from the same mechanism as the quadrupole, octopole and other large scale multipoles.

Variation in density violates the CP…But at this point you don't stop for contradictions, do you? Well, we do skip consequences of contradictions.

The consequence is an inevitable uncertainty in how the large scale CMB multipoles appear to us – the very fluctuations that are being measured will result in the Universe appearing slightly different to observers in another place, on about the same scale, but there is no way of determining purely from the CMB anisotropy spectrum where within the structure we are. This uncertainty is called cosmic variance and is greatest at low multipoles. It is illustrated in Fig 6 and Fig 7 by the shaded portion towards the left hand side of the graphs. *Cosmic variance is a source of cosmic anisotropy within a basic ΛCDM model.*

Cosmic variance is inherently at odds with the CP. It says that our limited view of the universe – within the event horizon - may be variant with the rest of the universe and give us a false picture of the

whole cosmos . Not only does this conflict with CP, it says we can't ever validly test the CP….. and contrary to the claims that homogeneity has been discovered beyond 256 Mpsc??? Check value)

We'll return to this subject in Section 6 below.

But suppose these anomalies are caused not just by cosmic variance but are pointers to some large scale and cosmic anisotropy or inhomogeneity in the Universe of a magnitude that fundamentally challenges the Cosmological Principle. Suppose the Universe is substantially different at different places and in different directions. The consequence of this for cosmology would depend in what way it departs from perfect homogeneity and isotropy and by how much. What does any violation of the Cosmological Principle mean for the Copernican Principle? Suppose it is so much violated that we have to abandon the FLRW metric for some other mathematical description at the cosmological level. Well, *even if the Universe is substantially inhomogeneous and anisotropic on the largest scales, that does not lead to the conclusion that the Earth is in any special or privileged place and so we could not conclude from that the Copernican Principle is violated.*

The CP is violated by the CMB alignments and the geocovariance principle.

The observation stands that the Earth is a planet orbiting one of billions of ordinary stars located in an unremarkable place in the spiral arm of an ordinary galaxy, which is one of billions of galaxies. That observation has not been modified by any recent observations.

Wrong…Sky observation finds all cosmic objects in motion, as seen from an immobile Earth. Up to Copernicus and Galileo, all the ancients believed their eyes , something moderns cannot seem to do.

In order to demonstrate that a violation of the Cosmological Principle results in the Earth being a special or privileged place, one needs at least a clear definition of what is meant by being in a special or privileged place. Well, at least we know what the New Geocentrists mean by it – they mean that the Earth is physically static and at the precise centre of the Universe. Violations of the Cosmological Principle in themselves are not evidence for this.

By the way, *what the geocentrists need to support their ideas is a Universe that is inhomogeneous but which appears isotropic from the point of view of the Earth*, because they think the Earth is static at the centre.

False…we already know that the view from earth is anisotropic in the CMB dipole and the other aether winds(M-GX)

If I were a geocentrist, I'd be rather worried by these CMB anomalies. In general the anomalies are challenges to large scale isotropy.

Red herring alert… GC doesn't require isotropy…it's a just an anomaly in Alec's thinking.

If we were literally positioned at the centre of a finite, bounded, spherically symmetric, flat Universe (the sort of Universe the geocentrists believe in), then we would observe isotropy, even if the Universe is inhomogeneous (which it would be bound to be if it is finite and bounded). *Anisotropies of the kind that might cause the observed anomalies would exist away from the centre and not at it, so these anomalies are evidence against their position rather than in support of it.*

The red herring continues… the speed of light depends on aether motion…so all observations with SoL dependence – like the CMB – will vary with aether motions.

5.2.4 Geocentrist argument #4: "There are anomalies in the CMB anisotropy, and therefore the Standard Model of cosmology must be abandoned."

As we have seen*, the CMB data is in excellent agreement with the Big Bang inflation ΛCDM model.*

Straw man again …. CMB alignments challenge inflation….. Resistance to ad hoc solutions challenges inflation..

The detailed prediction for the CMB anisotropy spectrum has been met very closely by the observations and rather than demolishing the model, it has provided excellent evidence in support of it. The anomalies appear to be secondary unexplained features on the overall structure. The overall structure, in most respects, matches very well. Therefore the approach that most cosmologists are taking is to continue working with the Standard Model while seeking explanations for the anomalies in the CMB data and in other observations. **At the moment there is no reason to think that it will be impossible to explain the anomalies by refining the vanilla Standard Model to incorporate some currently unrecognised process, which might or might not involve new physics.**

The CMB axis of evil is just one piece of evidence …like geocovariance… that supports a GS/GC cosmic model.

Of course, in the future it is possible that these anomalies, along with further observations, will falsify some crucial aspect of the Standard Model, and then cosmologists will have to seek something better. At the moment however, *the Standard Model, including inflation, dark matter and dark energy predicts what we see very well, and has received improved support from Planck and WMAP data, and so it remains an excellent cosmological model, and the best currently available.*

….if you ignore all the refuting evidence…not just CMB issues.

The Universe does not have to conform to our preconceptions. There is no guarantee that the physics of the Universe is simple, and no reason to think that we won't continue to discover more about the details the closer we look. *Geocentrists project their own way of doing "science" on to professional scientists.*

Alec uses untestable assetions as evidnce.
ALFA uses experimental evidence as evidence.
Which one is following the testing rule of the sci method?

They are wedded to a particular *a priori* conclusion and so they think the professionals are the same. They fear and ignore evidence contrary to their conclusion, so they believe that the professional must do the same. In fact, *cosmologists and astrophysicists welcome novel signals*

And that's why they treat conflicts with their ideology with moral judgments (Axix of Evil).

(and the anomalies can be regarded like that) that lead to better understanding of known processes or the discovery of new processes. If you read the primary literature, you'll find that that is the tone of the discussion about the detection of the anomalies – people are intrigued and excited by what they might mean rather than fearful that they might destroy some cherished theory.

5.3 The geocentrists lack a model

Sungenis, DeLano and their friends are very good at sitting on the side-lines and throwing bricks at the scientific community *but they haven't felt the need to create a model of their own.*

Published 3 years ago – the ALFA model , with the Geocovariance principle.

To the extent that they do research, it is by textual exegesis or literary analysis of scientific papers, lacking as they are in mathematical skills, the real language of physics.

Response…

I covered this briefly in Sec 5.2.1 above, but we'll look at it in more detail here. If you read the books and papers promoted on their websites and blogs (Galileo Was Wrong, Magisterial Fundies, geocentrism.com and so on), you will find that they are quite antagonistic to science in general, particularly physics after Copernicus and biology after 1859. Concentrating on cosmology and astrophysics, *here are some of the things that they are opposed to*: the Big Bang, an old Universe, *a Universe bigger than a few thousand light years across,*

I have no position on the size of the universe..

inflation, Special Relativity, General Relativity, quantum physics, the expansion of the Universe, redshift correlations with distance, Newtonian gravity on extra-galactic scales, the abandonment of the luminiferous Aether, an infinite Universe, an unbounded Universe, curved spacetime, non-Euclidean geometry of space, dark matter, dark energy and so on. (Of course *their opposition is based entirely on blind prejudice since they don't possess the mathematical skill or grounding in physics to understand or properly assess what they reject).*

What is the evidence I don't possess the mathematical skill or grounding in physics to understand or properly assess what I reject…

And, based on your essays of GC, that you possess the mathematical skill or grounding in physics to understand or properly assess what you reject

They spend much of their energy impotently opposing one or other of these concepts (quite often using one, which they deny, as an argument against another, which they are trying to deny – consistency is not their strong suit) but *very little energy, indeed none at all, in developing a model that is cosmologically and astronomically valid and self-consistent, and which supports their assertions.*

You are obviously ignorant…… of what I have published.

Such a model should explain all of the huge quantity of observations of the cosmos,

The details all in due time , after the ALFA model is accepted and the funding now devoted to MS obsessions, are redirected to aether research.

from the linear relationship between distance and luminosity of standard candles, such as standard Cepheid variables, to the detailed measurements of the CMB that we have been discussing here.
Their theory should explain the flat rotation curves of galaxies, the non-proportionality in redshift and luminosity of Type 1a supernovae, the relative abundance of the elements, the baryon density, and the structure of the Universe as far as stars, galaxies and galaxy clusters are concerned. They would have to explain the development of the early Universe and have a good solution for the Horizon, Flatness and Magnetic Monopole problems. Presumably they would need a new theory of gravity since they reject Special and General Relativity (and their novel theory of gravity would also have to be consistent with observations and all the tests that SR and GR have passed[59]). They would need to do all this with a model that is self-consistent (so it must have no major internal inconsistencies and contradictions), quantified (so it would have to be mathematically based) and provide at least the same, and preferably better, quantifiable predictions as the model it replaces (so for example it would have to predict the first peak in the CMB anisotropy power spectrum at l=220 plus the location of the other peaks).
That's a tall order for a handful of people who mostly have neither physics education nor mathematical skill.

A realistic world-view and adherence to the sci method has higher importance.

After all, the Standard Model has been developed by tens of thousands of professionals over more than a hundred years. You might accuse me of being unfair and you'd be right. We shouldn't expect them to be able to do this. But on the other hand, *if they can't even set out the bare-bones framework of such a model that doesn't fall at the first empirical hurdle, and which has at least the potential to meet the criteria above, how do they* *know that the standard model that they are opposed to is as wrong as they say it is?*

By ignoring the ALFA model you convict yourself of the same charges.

So, let's narrow down our challenge somewhat. Let's ask a specific question about the CMB anomalies that the geocentrists should be able to answer if they are in a position to support their claims with evidence and logic. *How precisely do the anomalies of the CMB support the geocentric argument?*
By identifying the aether boundaries that drive the cosmic motions….

It's not good enough to point to current unexplained observations, and from there to jump with a hand-wave to whatever conclusion they want.*"Scientists don't currently know why the quadrupole and the octopole align approximately with each other and on the dipole and ecliptic therefore the Earth is at the centre of the Universe"* is not a compelling argument, but it is basically the argument that they are making. "*"Scientists don't currently know why the quadrupole and the octopole align approximately with each other and on the dipole and ecliptic therefore the Earth is at a privileged or special place"* isn't any better.
If objects fell up under gravity, then we know that attraction of masses is not true.
The CMB alignments tellus that something is rotten in MS theory… and possibly all of it is.

The question to the geocentrists is: if the Universe is rotating daily about the Earth fixed at its centre, on an axis running through the terrestrial poles (i.e. on the equatorial plane) as they believe*, why would we expect the large scale multipoles of the CMB anisotropy to be aligned to each other and the ecliptic?*

Aether response…again

To answer the question they need to come up with a plausible hypothesis for the source of the CMB, which is consistent with its temperature and its black body spectrum, and which makes a stab at predicting the richness of the observed statistics of its anisotropy. That hypothesis should include a quantified explanation of how the daily rotation of the Universe about the fixed earth at its centre on the plane of the Earth's equator leads to the approximate alignment that we observe between the low multipoles, the dipole and the ecliptic. *At the very least it should explain quantitatively how the observed alignments are evidence for a central Earth.*

More aether response

Is that also too difficult? Well, perhaps *they could demonstrate that the anomalies are such that the FLRW solution to the Einstein field equations is an unacceptable approximation*[60] *and that cosmology should be based on a different metric?*
GR is an inconsistent pseudo-theory.

In doing so they would need to start with their explanation of the nature of the CMB and its anisotropies as before, derive the quantified cosmological consequences of the anomalies and *show that those consequences result in a metric that is significantly different from that given by the Friedmann equations*.
The metric is Euclidean. Aether causes interaction , creation and annihilation of matter.

This is what any scientist who claims that the Universe model should be based on a different metric would be required to do. Why not Sungenis, DeLano and friends?
In conclusion, the *geocentrists lack a self-consistent, coherent cosmological model.*

ALFA again

Their arguments are all based on ad-hoc considerations and they are unable to point out, beyond vague hand-waving, how the anomalies that they make such a song and dance about are actually evidence for their case. Their claims are unwarranted.

Ignorance of ALFA again…

6 Looking beyond the CMB

Although we have focused mainly on the CMB anomalies in this review, there are some other considerations that are relevant to the question of whether the Universe is homogeneous and isotropic that we will consider in this section.

6.1 Alternatives to dark energy – cosmic voids

You will remember from Section 3.5 that dark energy was proposed to explain the apparent acceleration of the expansion of the Universe and to make the total mass/energy density in the universe close to the critical mass. Almost at the same time as the hypothesis of dark energy was proposed, a number of other proposals were made to explain the supernova 1a data (the observation that the luminosity or brightness of type 1a supernovae dims more than expected with distance). The most interesting of these proposals and the one that has lasted longest is the idea that we live near the centre of a cosmic void[61] [62].

The idea is that what can be interpreted as accelerated expansion in a perfectly homogeneous universe, can also be interpreted as being caused by the observer being near to the centre of a large under-dense region of the universe, which would imply that the universe is inhomogeneous on at least that scale. This proposal neatly avoids the need for dark energy and is therefore being actively explored.

More CP violation to get around the dearth of dark energy

Observations, such as the uniformity of the CMB, indicate that we would need to be within 15Mpc (or about 50 million light years) of the centre[63] of such a void (or further away from the centre but moving towards it).

Abstract of [63]:

..., we investigate whether such an off-center location can explain the observed alignment of the lowest multipoles of the CMB map. We find that the observer has to be located within a radius of ∼ 15 Mpc from the center for the induced dipole to be less than that observed by the COBE satellite. But for such small displacements from the center, the induced quadru- and octopoles turn out to be insufficiently large to explain the alignment.

So even if we:

- **Ignore the contradiction that the MS BB center is the CMB center when the CMB data indicates the CMB center is very near to Earth, if not the Earth.**
- **Violate the CP by assuming Earth is in a universe's low density zone**
- **Assume we are within a distance of 0.003 of the universe's radius,**

This still cannot force the predicted CMB npoles to match the real, observed npoles…

It has been suggested that being off-centre in such a void can explain some of the anomalies of the CMB anisotropy (alignment of the low multipoles and asymmetry between hemispheres)[64].

Assumes a GR model , making it unacceptable *ab initio*

The size of the putative void has been constrained by observations of a particular physical phenomenon called the kinetic Sunyaev-Zel'dovich effect to be less than 4.5 billion light years, which is smaller than the observable universe[65]. In order to match other observations, such as the position of the first peak in the CMB anisotropy power spectrum, the Universe outside the under-dense region would have to be homogeneous on the scale of the cosmological horizon[66] and above. A large number of other papers have been published on this subject including reviews[67]. *Astrophysicists and theorists have been developing mathematically based models of the universe that represent the void in order to compare their predictions with observations.* The most common of these models describe a region that is spherically symmetric but inhomogeneous, and expanding or collapsing under the influence of GR gravity. *....To model the void, they use a spherically symmetrical and inhomogeneous solution to the Einstein field equations called the Lemaître-Tolman-Bondi (LTB) solution* that was first proposed by Richard Tolman in 1934[68] and further developed by Hermann Bondi in 1947[69].

GR rejection again.

The models of the Universe with a void comprise an inhomogeneous spherical region or void in an otherwise homogeneous universe. The homogeneous background is represented by the FLRW metric that we discussed earlier, confined to matter only and flat space (this constrained version of the Friedmann solution is also known as an Einstein-deSitter space). The transition between the LTB and the Einstein-deSitter space has been modelled in a number of ways[70]. There also exists a hypothesis in which a series of spherical shells of increasing radius, each shell having different matter density, blend into the homogeneous flat universe beyond the void[71].

So far, observations do not definitively favour the Standard Model with accelerating expansion over an inhomogeneous cosmic void. However, recent measurements do favour the Standard Model and disfavour cosmic voids, and the most likely varieties of cosmic void have been excluded. A recent direct measurement of cosmic homogeneity using the WiggleZ spectroscopic survey of 200,000 galaxies[72] favours the Standard Model. More recently, the BOSS experiment, which uses the preferred spacing of galactic structures based on the huge Sloan Digital Sky Survey III, more strongly favours the Standard model[73]; in other words BOSS is compatible with a homogeneous universe undergoing accelerating expansion. We'll discuss the BOSS experiment in somewhat more detail below. Even more recently, a study by the Planck team of the motion of galaxy clusters in the search for an average bulk flow against the CMB rest frame concluded that no such flow existed. Moreover the data rules out adiabatic voids that have sufficient depth and size to correctly predict the Sn1a data[58]. Measurements of the Hubble constant yield a value that is generally higher than is predicted by the void models[74] and therefore disfavour the void hypothesis. We can therefore say that although void models proposed to explain the Sn 1a data are not currently ruled out, they are highly disfavoured by observations.

The geocentrists' reaction to these suggestions is typical sensationalism. They claim that *if a void turns out to be the cause of the dimming of distant type 1a supernovae then this will disprove the Cosmological Principle and with it the Copernican principle and the Big Bang. Furthermore they claim* *that since many of the void models constrain our current location to be near the centre of the void then that is evidence or proof that we are in a special place or even that we are at the centre of the Universe.*

Well, yeah.

This rhetoric is highly exaggerated. Even if the explanation that we live near the centre of a cosmic void becomes accepted in the future, that will not ipso facto invalidate the Big Bang. In the void models, the voids are imbedded in a larger surrounding homogeneous space and that, and the fact of ongoing expansion of the Universe, would continue to support Big Bang. Physicists would, of course, wish to explain how the void arises within a Big Bang scenario. However, the Big Bang is not incompatible with the existence of a cosmic void of the kind proposed. In fact a number of proposals exist[75] for how such a void can arise as a result of primordial anisotropies within a Big Bang model.
The geocentrists' claims that the void proposal is evidence for or proof that the Earth is in a special place or even that the Earth is at the centre of the Universe are even more greatly exaggerated. *The void hypotheses only require the Earth to be near the centre of the void (and 'near' in this context means less than 50 million light-years – or 500 Milky Way diameters, so not really that near;*

Repeat abstract for [63]

the geocentrists claim that the Earth is the exact centre of the universe,

In my case that would include the validity of the GeoCoVariance Principle

and the Sun, 8 light-minutes away, is not at its centre. I'm sure readers can see that 50 million light-years is a lot more than 8 light-minutes) and being near the centre of the void does not mean the same as being near the centre of the Universe. The proposition that the dimming of the SN1a supernovae arises from our location within 50 million light years of the centre of a cosmic void or under-density, even if that idea were to be more certain than an unconfirmed hypothesis, is not evidence for geocentrism.

6.2 The puzzle of the radio galaxy dipole amplitude

Radio galaxies are those that emit and are detected at radio wavelengths. Several very extensive catalogues of radio galaxies containing data on hundreds of thousands of galaxies have been gathered. Galaxies do move with respect to one another – in fact the velocity of nearby galaxies with respect to our own can be readily measured, and the *velocity of the Milky Way galaxy with respect to the CMB rest frame is one component that creates the CMB temperature dipole*.

The velocity of a Doppler shift is relative…. The Leo source can also be moving towards the Earth rest frame at 373 km/s…

Or – as in the ALFA model, aether can be streaming towards Earth at 373 km/s, causing SoL to become c +v…

However, *in a homogeneous universe, we would expect the* mean *velocity of a large number of galaxies in all directions of the sky to be zero with respect to the rest frame of the CMB, so the mean velocity of the solar system with respect to the radio galaxies should be the same as it is with respect to the rest frame of the CMB as derived from the CMB dipole*.

Perfectly confusing…

The solar system is now receding from the BB center…yet we don't know where the BB center is … MS resorts to 4Dim space(contrary to realism, where only three is what we see) where we are on a 3D expanding shell and the center has disappeared into the 4th dim..!

-we would expect the BB center – where all radiation originally came from, - to be the CMB center …but the galaxies in the LEO direction shows variable red-shift recessions, just like the rest of the sky….there are no no blue-shift in Leo's galactic sources…the blue shift is in the CMB dipole.

The mean velocity of the receding galaxies should be the same as Earth's …. if BB were a rational model,

???? complete

Several analyses have been carried out to measure the mean radio galaxy velocity[76].
The method of measuring the mean velocity of the radio sources is not what you might think. The Doppler shift of each galaxy is not measured directly, but the galaxies above a certain arbitrary threshold of flux are counted. In the direction of motion of the solar system we should find more galaxies above the threshold (since the energy of the photons is increased by Doppler shift) than in the opposite direction (where the energy of photons is reduced by Doppler shift). And indeed all the analyses carried out, bar one, yield a result where the direction of the motion with respect to the mean of the radio galaxies is in the same direction (within errors) as the CMB dipole. That is exactly as expected.

What is unexpected is *that the detected velocity ranges from two to five times the velocity measured from the CMB*[77]. *As yet there is no agreed explanation for this.*

The mean galaxy velocity was supposed to be the same as the CMB frame!! Technically, this is what is called a contradiction…
Does it reflect anisotropy in the universe on the scale of the current surveys? It is possible that it arises as an artefact of assumptions made in the analysis about the spectral characteristics of the radio sources, the statistical distribution of radio intensities and physical distribution of radio galaxies which is known to be inhomogeneous and anisotropic on medium scales. Another possibility is that it arises from an average flow of galaxies with respect to the rest frame of the CMB within the scale of the survey.
It is also possible that the discrepancy in the velocity of the solar system inferred from the CMB and the radio galaxy dipoles can be explained in the context of a local under- or over-density such as we have discussed before[78]; such a possibility is discussed in a paper that has recently been made available[79]. In this case, some of the dipole can be explained by the existence of a void rather than being a result of the motion of the observer – in other words a void would result in a radio galaxy dipole that depends at least partly on cosmic structure rather than the motion of the observer.

Such a result could arise for cases where the observer is either inside or outside the void.
It is surprising that the New Geocentrists think that this is good news for their case. Whether or not these data ultimately support the conclusion that the Universe contains features that are unexpectedly inhomogeneous, *the existence of a large radio galaxy dipole (and anisotropies in the measurements of polarisation direction of quasars[80], indeed any anisotropy on a large scale) is evidence against the idea that the Earth is at rest in a central or privileged place, in which scenario one would expect the Universe to look identical in all directions.*

Straw man alert… the CP is conflated with GC ….when no such link was ever made.

CP is independent of GC

6.3 Periodicities in galaxy redshifts

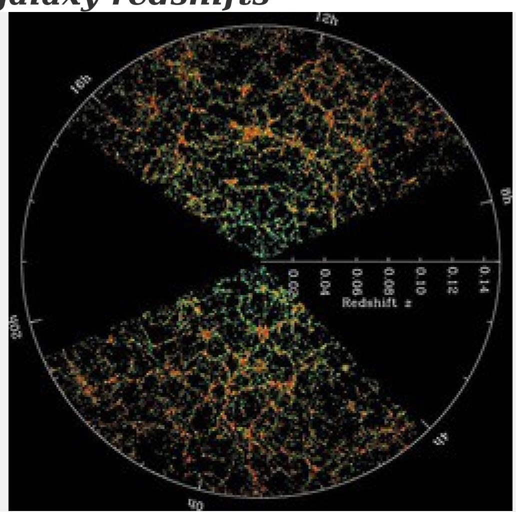

Fig 10: Slices through the SDSS 3-dimensional map of the distribution of galaxies. Earth is at the center, and each point represents a galaxy, typically containing about 100 billion stars. Galaxies are colored according to the ages of their stars, with the redder, more strongly clustered points showing galaxies that are made of older stars. The outer circle is at a distance of two billion light years. Both slices contain all galaxies within -1.25 and 1.25 degrees declination. Credit: M. Blanton and the Sloan Digital Sky Survey. http://www.sdss.org/

The idea that galaxies are arranged in shells at preferred distances around the Earth and that therefore the Earth is at the centre of a vast large-scale structure has been proposed for some time (this idea is known as redshift quantisation or periodicity). Standard cosmology predicts that the galaxy clusters would condense into large scale strings and nets, called the Cosmic Web, and indeed that is what is observed (see Fig 10). It seems to be the case that early reports of redshift quantisation based on relatively small catalogues of galaxies, mistook the local galactic network as evidence in support of periodicities. Once extensive galaxy surveys became available, *the idea that the distribution of galaxies and galaxy clusters are quantised and centred on the Earth has been shown to be false*[81]

From [81] " all galaxies in the 2dFGRS, use their redshifts to estimate thei r distance (adopting a Hubble constant of 60kms − 1Mpc − 1)"

Using the Hubble variable for distance is rejected , as before. This vitiates the study.

or at least not well established[82].

Stellar symmetry and quantization cannot be resolved until a correct distance determination can be made….. The Hubble Law is not such.

Nevertheless we need to ask whether there is any sort of preferred scale or structure in the galaxies. Referring back to Sec 2.4 let's remind ourselves of the acoustic waves in the early universe known as Baryon Acoustic Oscillations. You will remember that these BAOs intensified the primordial anisotropies in the CMB at certain scales and suppressed them at other scales, and this is the explanation for the existence and position of the first peak in the CMB anisotropy power spectrum (Figs 6 and 7). The fluctuations in the density of matter at the time of decoupling, which were the cause of the CMB temperature anisotropies, were also seeds for the gravitational condensation of matter into galaxy clusters and superclusters. *We therefore expect to see structures in the current universe that have preferred dimensions corresponding to the peaks of the CMB anisotropy*.

Instead, we see the CMB patterns aligning with solar system boundaries ..the equinox and ecliptic.

The preferred dimension for the first peak in the CMB when converted to the current universe by applying the expansion factor of the universe since decoupling is about 150Mpc or about 500 million light years. The Sloan Digital Sky Survey III experiment, *Baryon Oscillation Spectroscopic Survey* (BOSS)[83], was designed to detect and measure this effect. BOSS finds that the structures in the universe have preferred scales in good agreement with the BAO model, in other words, galaxies are clustered at preferred scales (but at randomly located centres – BAO structures are not the same as redshift periodicity) predicted by the physics of the acoustic oscillations[84]. By measuring the dimensions of the preferred scales for structures a long distance away, and therefore a long time ago, BOSS is able to measure the rate of expansion of space in the past and therefore determine whether the universe is undergoing accelerated expansion. BOSS is therefore an independent check of the conclusion based on the Type 1a supernova distance-luminosity data that indicated accelerating expansion. The BOSS data supports accelerating expansion and is entirely consistent with the hypothesis of dark energy.

In 2007, John Hartnett and Koichi Hirano carried out a Fourier analysis of the redshifts of galaxies in the 2dF GRS and SDSS galaxy survey catalogues, and claim[85] that there is a detectable periodicity in the number of galaxies at particular redshifts. This could indicate that galaxies are preferentially located on concentric shells with dimensions corresponding to those redshifts assuming an approximately constant Hubble expansion. Hartnett and Hirano suggest that the redshift periodicity (which appears in redshift space rather than distance or wavenumber space[86]) might be caused by oscillations in the expansion rate of the past universe, a hypothesis which Hirano is pursuing in the literature[87]. Bell and Comeau[88] have reported similar apparent oscillations in the expansion rate based on Type 1a supernova data.

The interpretation of the data by Hartnett and Hirano[85] has been challenged on-line by Tom Bridgman[89]. He claims that the existence of enhanced spatial frequencies in their one-dimensional analysis of a three-dimensional data set does not mean that the data is periodic; and that the proper way to carry out a spatial frequency analysis on a 3-D data set is to perform a full 3-D transform on the entire data set. Interestingly, Hartnett has reported[90] that apparent periodicity in quasars from the Sloan Digital Sky Survey is not real but is a selection effect – in other words it is caused by an artefact of the measurement or analysis.

Setting aside Bridgman’s objections for the sake of argument and *accepting that the data does support the periodicity hypothesis, and assuming it is caused by oscillations in the expansion rate of the universe in the past, as proposed by Hartnett and Hirano, let’s consider what implications that has for geocentricity.*

There are no implications…. oscillations in the expansion rate of the universe in the past is untestable and thus rejected as a premise…

In that case, observers will see preferential clustering of galaxies as a function of redshift, in concentric shells exactly centred on themselves *from wherever in the universe they make the observation*. Just like the recession of galaxies in a uniformly expanding universe always appears to be exactly centred on the observer, so universal oscillations in the expansion rate would leave a signature in the redshift data precisely centred on the observer, *wherever he is*. At first sight it might seem strange that you can see the same effect of shells of increased density centred on yourself wherever you are, but we can understand this if we consider that we are looking back in time as well as looking across space when we look at galaxies a long way away. If the universe was expanding less slowly, say, 100 million years ago, then we would see an increased density of galaxies at the redshift corresponding to a look-back time of 100 million years (in other words we'd be looking at the density as it was 100 million years ago), which lies on a shell centred on us because it has taken 100 million years for the light from that time to reach us from all directions in space; and everyone else in the Universe will see the same thing. So, even if this controversial periodicity analysis is confirmed, it is not evidence that the Earth is at the centre or at a special place.

In the original paper, Hartnett and Hirano refer only to the oscillating expansion rate hypothesis. *In a second sole-author paper[91], Hartnett explores the possibility that the periodicity in the data is caused not by an oscillating expansion rate but by anisotropic co-existing expanding shells of increased galaxy count*.

Hartnett uses the Hubble conjecture….. rejected

If that were the case the data would look different depending on where in the universe the observer is. Hartnett has calculated that the data supports this scenario, if the centre of the shells is 137 million light years away from us. Hartnett very fairly and clearly presents these alternatives on his blog[92]. Neither alternative supports strict geocentrism. According to the first hypothesis the same data would be obtained from any vantage point in the Universe and so provides no support for geocentrism; and according to the second, the centre of the shell structure is displaced from the Earth by 137 million light years.

7 Conclusion

I have reviewed the discovery, science and characteristics of the CMB. I have explored the Standard Model of the Universe and explained the rationale for the inclusion of its most important features. I have described the anomalies that have been discovered in the CMB and discussed their implications for cosmology. I have assessed the geocentrists' claims against this information. Finally I have considered a few other observations that are anomalous or that call the Cosmological Principle into question.

I have shown that the geocentrists' claims are not warranted by the science. Having started with a preconceived and unshakeable conclusion, geocentrists are engaged in a very unscientific process, mining for evidence that they believe supports their case or that they think they can serve up to an uninformed audience to persuade them that modern cosmology is in crisis and that geocentrism is set to replace it. Quite apart from the geocentrists' histrionic tone, their conclusions are generally unwarranted, chiefly because they do not follow from the science. *The geocentrists have no cosmological model of their own and they are unable to explain in detail how the observations support their case.*

Repeat ALFA model and aether winds

On many occasions, they misunderstand or misrepresent the science.

The anomalies in the CMB, and the other observations that we have reviewed do not support strict geocentrism, and they disprove neither the Copernican Principle nor the Standard Model of Cosmology. We have seen that observations in the last decade have reinforced rather than undermined the Standard Model. Of course, that is not to say that the Cosmological Principle of homogeneity and isotropy on the largest scales is sacrosanct. Astrophysicists and cosmologists publish and discuss many challenges to that concept, but even in the extreme case, geocentrism is not the natural successor to the Standard Model, should a substantially inhomogeneous universe model become accepted.

The basic fallacy of the geocentrists is to believe and to argue that evidence against the Standard Model and against the Cosmological Principle, such as it is, is evidence in favour of a geocentric cosmology. It's not.

Repeat ALFA plus aether winds.

Replace CMB center with center of the SLS……???

List all refs with reason for rejection

7 – GR factor rejected as experimentally
18- Guth – inflation
29- abstract: ..*Although these analyses represent a step forward in building an understanding of the anomalies, a satisfactory explanation based on physically motivated models is still lacking.*
[31] Planck Collaboration, *Planck 2013. Results. XXVII. Doppler Boosting of the CMB: Eppur si muove,* arXiv:1303.5087 where additional effects in the CMB (increased power in the anisotropies in the direction of travel and CMB aberration) are strong evidence that the dipole is caused by motion of the solar system relative to the CMB rest frame.
Need red-shift survey near Leo that has different velocities than CMB dipole…
[37] Bennett et al, *Nine-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Final Maps and Results,* arXiv:1212.5225
Uses LCDM

[38] Copi et al, *Alignments from WMAP and Planck,* arXiv:1311.4562v2
Abstract…, both the WMAP and Planck data confirm the alignments of the largest observable CMB modes in the Universe. In particular, the p-values for the mutual alignment between the quadrupole and octopole, and the alignment of the plane defined by the two with the dipole direction, are both at the greater than 3-sigma level for all three Planck maps studied. We also calculate conditional statistics on the various alignments and find that it is currently difficult to unambiguously identify a leading anomaly that causes the others or even to distinguish correlation from causation.
Body>….At the present time in cosmology there are no compelling alternative models that can account for the anomalies..

It is not even clear whether the origin of the anomalies is cosmological, astrophysical foregrounds, systematic (instrumental, map making, etc.), or simply statistical, although it could be argued that since the Planck satellite and data reduction is very different from that provided by the WMAP satellite, systematic effects are unlikely to explain the existence of shared anomalies…

….. Choosing a large mask will remove the most contamination but will also lead to a large variance, poor determination, of the full-sky information. In this work, our goal is to study the large-scale anomalies present in the full-sky data independent of their origin. If we were interested in only a cosmological origin for alignments, we would restrict the analysis to the cleanest portions of the sky by employing a large mask. A large mask washes out the results making definitive statements about the alignments impossible. On the other hand, employing a small mask allows for definitive statements about the presence of alignments but reduces the ability to determine their origin….

…y. The dipole is subtracted since our motion through the Universe with respect to the CMB is at a speed $\beta = v/c \sim 10^{-3}$, whereas the fluctuations are $\Delta T/T \sim 10^{-5}$ so the Doppler dipole is about two orders of magnitude larger than the expected cosmological CMB dipole. A Doppler quadrupole (DQ) – effect of the Sun's proper motion on the quadrupole – is also induced and expected to have a magnitude $O(\beta^2) \sim 10^{-6}$. Though this is small, it is not negligible, especially in our Universe which has a small cosmological quadrupole and when properties of the maps are being studied…..

…The CMB temperature (monopole) has been determined from the nearly perfect black body to be $T_0 = 2.7255 \pm 0.0006$ K (Fixsen 2009). Our direction through the Universe in Galactic coordinates is $(l, b) = (263.99^\circ \pm 0.14^\circ, 48.26^\circ \pm 0.03^\circ)$ with a speed $\beta = (1.231 \pm 0.003) \times 10^{-3}$ (Hinshaw et al. 2009). [**note the precision]**

…t there is an additional contribution to the speed due to the velocity of the satellite with respect to the Sun. This introduces up to about a 10 per cent variation in β at a non-constant direction with respect to the CMB…

…, the Doppler octopole should have a magnitude $O(\beta^3) \sim 10^{-9}$. Direct calculation shows that for all components the Doppler octopole correction has a magnitude less than about 10^{-4} of the observed octopole…

….The discovery of alignments, or any anomaly, that persist through multiple full-sky maps is striking given the different instruments, systematics, cleaning procedures, etc. It strongly suggests that there is at least some fundamental origin to them. The extent to which this origin is cosmological and the statistical significance of such an identification is difficult to determine….

…The alignment in the seven-year data is quite remarkable for being almost perfect ($|\hat{n}_2 \cdot \hat{n}_3| \simeq 1$)….

….the Ecliptic plane is seen to carefully thread itself between a hot and cold spot and there is a clear power asymmetry across the Ecliptic plane;…

…(ii) the planarity of the octopole and the alignment of the quadrupole and octopole planes is clearly visible – note the remarkable near-overlap of the quadrupole and octopole maximum angular momentum dispersion axes; (iii) the area vectors lie near each other, near the Ecliptic plane, and also near the dipole direction….

….alignments persist at the 95 to 99.9 per cent level, with the strongest alignment occurring with the dipole direction (> 99.6 per cent)….

….The alignments shown in Table 7 are peculiar, particularly the mutual alignment of the quadrupole and octopole area vectors as well as that with the dipole direction. A remaining question is the independence of these alignments….

….We find that the residual p-value for alignment with the dipole and Ecliptic Plane directions, given the mutual quadrupole+octopole alignment, is at the 2 to 6 per cent level, while the alignment with the Galactic pole is not significant. These results are in agreement with results in Copi et al. (2006) (see table 4 in that paper), and indicate that even given the relative location of the quadrupole and octopole area vectors (i.e. their mutual alignment), the Ecliptic plane and dipole alignments are unlikely at the 95 per cent level….

….If we assume the observed levels of alignment with the Ecliptic plane or the Galactic poles, the quadrupole+octopole alignment remains anomalous at the 1 to 4 per cent level for WMAP. For Planck the conclusion is not clear, however all p-values remain below 20 per cent. The situation is different for the dipole. We see that assuming the observed level of dipole alignment, the quadrupole+octopole alignment seems to be quite plausible. This suggests that the dipole alignment (which is also the most significant and robust alignment in Table 7) could be the reason for the other observed alignments….

Conclusion: …The largest structures in the microwave sky, the quadrupole and octopole, are aligned with one another and with physical directions or planes – the dipole direction and the Ecliptic plane. These alignments, first observed and discussed in the one-year WMAP data, have persisted throughout WMAP's subsequent data releases, and are now confirmed in the one-year Planck data. …. this is surprising: cleaned, full-sky maps are required to see these alignments, and the removal of foregrounds, along with other systematic effects, makes it challenging to accurately produce full-sky maps on large angular scales. …Qualitatively, the main anomalies detected in earlier WMAP releases remain: the quadrupole and octopole are aligned with each other; the normal to their average plane is aligned with the dipole – the direction of our motion through the Universe; that normal is also close to the Ecliptic plane, so that the average plane of the quadrupole and octopole is nearly perpendicular to the Ecliptic plane. …. Ecliptic plane cleanly cuts between a hot and cold spot, thereby separating weaker quadrupole+octopole power in the north Ecliptic hemisphere from the stronger power in the south Ecliptic hemisphere. Quantitatively, statistics from the maximum angular momentum dispersion (Table 5) and the multipole vectors (Table 7 and Fig. 6) both show strong evidence for the mutual alignment of the quadrupole and the octopole. ….. The alignment of the quadrupole and octopole with the dipole (Table 7) appears at first sight even more robust than their mutual alignments, with p-values of less than 0.4 per cent (and as low as 0.05 per cent) in all maps and with both S and T statistics. The interpretation however is not clear. The dipole includes contributions from several sources, but is almost certainly dominated by the Doppler effect from the Sun's motion through the Galaxy, the Galaxy's motion through the Local Group, and the Local Group's motion through the more distant large scale structure; all giving comparable contributions. (A dominant or even significant contribution from a cosmological dipole seems remote.) …. it is difficult to envision physics that would connect the dipole, quadrupole, and octopole. A systematic error in the measurement or the analysis pipeline could connect them all, but the robustness of the alignment across the two satellites argues against that explanation. … As an attempt to disentangle correlation from causation between and among the alignments, we have studied their interdependence by calculating the conditional probability of alignment with a fixed direction given the observed mutual quadrupole+octopole alignment and vice versa. ….. For example, the conditional p-values for quadrupole+octopole+dipole alignment given either the observed quadrupole+octopole alignment (Table 8) or at least the observed quadrupole+octopole alignment (Table 9) are 3 to 10 per cent. These are consistent with the 4 to 6 per cent found in Copi et al. (2006) for the conditional p value of the quadrupole+octopole+dipole alignment given the observed relative directions of the quadrupole and octopole area vectors. ….. A priori, less scepticism could be attached to a possible physical explanation for the correlation between the quadrupole+octopole and the Ecliptic plane. If the underlying cosmological quadrupole and octopole were unexpectedly absent, then we could well imagine a Solar System (or even nearby Solar neighbourhood) source for the quadrupole and octopole correlated with the plane of the Solar System. Nevertheless, there are no proposed viable physical models that correctly reproduce the observed arrangement of quadrupole and octopole extrema lying on a plane perpendicular to the Ecliptic and well separated by it. The statistics offer only weak, and even confusing, guidance as to what is correlation and what, if anything, is causation. The statistical situation is no clearer for correlation with the Galactic pole. Unfortunately, the fact that the dipole direction simply happens to be just off the Ecliptic plane, which passes about 30 degrees from the Galactic poles, makes establishing the priority of one correlation over another difficult just on the basis of statistics of CMB temperature data. Some, or all, of these correlations are presumably accidental. **Solving this puzzle will require data other than just CMB temperature maps, and probably a model that can be tested against such data**.

…. In summary, the quadrupole and octopole alignments noted in early WMAP full-sky maps persist in the WMAP seven-year and final (nine-year) maps, and in the Planck first-year full-sky maps. The correlation of the quadrupole and octopole with one another, and their correlations with other physical directions or planes – the dipole, the Ecliptic, the Galaxy – remain broadly unchanged across all of these maps. Consequently, it is not sufficient to argue that they are less significant than they appear merely by appealing to the uncertainties in the full-sky maps – such uncertainties are presumably captured in the range of foreground removal schemes that went into the map making. It similarly seems contrived that the primordial CMB at the last scattering surface is correlated with the local structures imprinted via the Integrated Sachs-Wolfe (ISW) effect in just such a way to generate the observed alignments, … While it may be tempting to explain away the observed large angle alignments in the CMB by postulating additional, unspecified corrections to the maps, such explanations so far have not been compelling. Numerous corrections have been applied in the data analysis pipelines, and they have also evolved between the initial WMAP data releases and the Planck first-year release, yet the alignments remain. …. We think it is preferable to acknowledge that the existence of anomalies seen in the WMAP and Planck maps at large angular scales may point to residual contamination in the data or to **interesting new fundamental physics**.

[39] Bennett et al, *Seven Year WMAP Observations:Are there Cosmic Microwave Background Anomalies?,* arXiv:1001.4758

Uses LCDM

The quadrupole and octupole components of the CMB sky are remarkably aligned, but we find that this is not due to any single map feature; it results from the statistical combination of the full-sky anisotropy fluctuations. It may be due, in part, to chance alignments between the primary and secondary anisotropy, but this only shifts the coincidence from within the last scattering surface to between it and the local matter density distribution. While this alignment appears to be remarkable, there was no model that predicted it, nor has there been a model that provides a compelling retrodiction. ….We confirm the claim of a strong quadrupolar power asymmetry effect, but there is considerable evidence that the effect is not cosmological. The likely explanation is an insufficient handling of beam asymmetries…

The alignment of the quadrupole and octupole was first pointed out by Tegmark et al. (2003) and later elaborated on by Schwarz et al. (2004), Land & Magueijo (2005a), and Land & Magueijo (2005b). The fact of the alignment is not in doubt, but the significance and implications of the alignment are discussed here…

…Park, Park, & Gott (2007) also assess the WMAP Team's ILC map and conclude that residual foreground emission in the ILC map does not affect the estimated large-scale values significantly. Tegmark et al. (2003) also performed their own foreground analysis and conclude that their CMB map is clean enough that the lowest multipoles can be measured without any galaxy cut at all. ….. de Oliveira-Costa & Tegmark (2006) believe that it is more likely that the true alignment is degraded by foregrounds rather than created by foregrounds.

The probability that l = 2 and l = 3 multipoles would be aligned is shown in Figure 12. The < 1 ◦ alignment in our sky appears to be quite improbable based upon random simulations of the best-fit ΛCDM model. ….. The probability of two axes randomly aligning in the same pair of pixels is then 2/196,608 = 0.001%. **The probability of getting an alignment within 0. 25◦ of a given axis is 0.00095%, which is close to 0.001% above**.

…….Masking Cold Spot I eliminates any significant alignment. However, keeping that region but masking other regions also significantly reduces the quadrupole–octupole alignment. The posterior selection of the particular masked regions is irrelevant as the point is only to demonstrate that no single region or pair of regions solely generates the < 1 ◦ alignment. Rather the high degree of quadrupole– octupole alignment results from the statistical distribution of anisotropy power over the whole sky. This rules out single-void models, a topological defect at some sky position, or any other such explanation. The alignment behaves as one would expect if it originates from chance random anisotropy amplitudes and phases. The alignment of the l = 2 and l = 3 multipoles is intimately connected with the large-scale cool fingers and intervening warm regions, discussed earlier, as can be seen in Figure 14. Although the alignment is indeed remarkable, current evidence is more compatible with a statistical combination of full-sky data than with the dominance of one or two discrete regions….

….We distinguish between a "hemispherical" power asymmetry, in which the power spectrum is assumed to change discontinuously across a great circle on the sky, and a "dipole" power asymmetry in which the CMB is assumed moduFigure 14. l = 2 quadrupole and l = 3 octupole maps are added. The combined map is then shown superposed on the ILC map from Figure 2. Note that the quadrupole and octupole components arrange themselves to match the cool fingers and the warm regions in between. The fingers and the alignment of the l = 2 and l = 3 multipoles are intimately connected. lated by a smooth cosine function across the sky, i.e., the CMB is assumed to be of the form T (n)modulated = (1 + w · n) T (n)unmodulated. (12) Previous analyses of WMAP data in the literature have fit for either hemispherical or dipolar power asymmetry, and the results are qualitatively similar: asymmetry is found with similar direction and amplitude in the two cases…

….Furthermore, theoret-12 ical attempts to obtain cosmological power asymmetry by altering the statistics of the primordial fluctuations (Gordon 2007; Donogue, Dutta & Ross 2009; Erickcek, Kamionkowski & Carroll 2008; Erickcek et al. 2009) have all found a dipolar modulation rather than a hemispherical modulation. Therefore, we will concentrate on the dipolar modulation, defined by Equation (12), for the sake of better comparison with both early universe models, and with similar analyses in the literature. Unambiguous evidence for power asymmetry would have profound implications for cosmology….

…The claimed statistical significance of the quadrupolar power asymmetry is so high that it seems impossible for it to be a statistical fluke or built up by posterior choices, even given the number of possible anomalies that could have been searched for…

…For example, no one had predicted that low-l multipoles might be aligned. Rather, this followed from looking into the statistical properties of the maps. Simulations, both by the WMAP team and others, agree that this is a highly unusual occurrence for the standard ΛCDM cosmology. Yet, a large fraction of simulated skies will likely have some kind of oddity. The key is whether the oddity is specified in advance….

…We find that the quadrupole and octupole are aligned to a remarkable degree, but that this alignment is not due to a single feature in the map or even a pair of features. The alignment does not appear to be due to a void, for example. We find that the alignment is intimately associated with the fingers of the large-scale anisotropy visible in the southern sky, and it results from the statistical combination of fluctuations over the full sky. There is also evidence that the alignment is due, in part, to a coincidental alignment of the primary anisotropy with the secondary anisotropy from the local density distribution through the ISW effect. At the present time the remarkable degree of alignment appears to be no more than a chance occurrence, discovered a posteriori with no motivating theory..

[40] Copi et al, *Large-Angle Anomalies in the CMB,* arXiv:1004.5602v2

The Copernican principle states that the Earth does not occupy a special place in the universe and that observations made from Earth can be taken to be broadly characteristic of what would be seen from any other point in the universe at the same epoch. The microwave sky is isotropic, apart from a Doppler dipole and a microwave foreground from the Milky Way. Together with the Copernican principle and some technical assumptions, an oft-inferred consequence is the so-called cosmological principle. It states that the distributions of matter and light in the Universe are homogeneous and isotropic at any epoch and thus also defines what we mean by cosmic time. This set of assumptions is a crucial, implicit ingredient in obtaining most important results in quantitative cosmology. For example, it allows us to treat cosmic microwave background (CMB) temperature fluctuations in different directions on the sky as multiple probes of a single statistical ensemble, leading to the precision determinations of cosmological parameters that we have today..

…Although we have some observational evidence that homogeneity and isotropy are reasonably good approximations to reality, neither of these are actual logical consequences of the Copernican principle. For example the geometry of space could be homogeneous but anisotropic

— like the surface of a sharp mountain ridge, with a gentle path ahead but the ground dropping steeply away to the sides

..Similarly, although the Earth might not occupy a privileged place in the universe, it is not necessarily true that all points of observation are equivalent. For example, the topology of space may not be simply-connected — we could live in a three-dimensional generalization of a torus so that if you travel far enough in certain directions you come back to where you started…

…

…, it is worth noting that our record at predicting the gross properties of the universe on large scales from first principles has been rather poor. According to the standard concordance model of cosmology, over 95% of the energy content of the universe is extraordinary | dark matter or dark energy whose existence has been inferred from the failure of the Standard Model of particle physics plus General Relativity to describe the behavior of astrophysical systems larger than a stellar cluster | while the very homogeneity and isotropy (and inhomogeneity) of the universe owe to the influence of an inflaton field whose particle physics-identity is completely mysterious even after three decades of theorizing.

….. It is known that dark energy can affect the largest scales of the universe | for example, the clustering scale of dark energy may be about the horizon size today. Similarly, inflationary models can induce observable effects on the largest scales via either explicit or spontaneous violations of statistical isotropy. **It is reasonable to suggest that statistical isotropy and homogeneity should be substantiated observationally, not just assumed.** More generally, **testing the cosmological principle should be one of the key goals of modern observational cosmology.**

….., statistical isotropy has begun to be precisely tested.

A xed angular scale on the sky probes the physics of the universe at a range of physical distances corresponding to the range of observable redshifts….. Angles of 1 degree and less probe events that were in causal contact at all epochs between the redshift of decoupling and today; this redshift range includes physical processes such as the secondary CMB anisotropies. The situation is different for angles > 60 degrees, which subtend arcs that enter our Hubble patch only at z < 1. Therefore, the primordial CMB signal on such large angular scales could only be modified by the physics of local foregrounds and cosmology in the relatively recent past ($z < 1$). Because they correspond to such large physical scales, the largest observable angular scales provide the most direct probe of the primordial fluctuations | whether generated during the epoch of cosmological inflation, or preceding it.

A. Statistical isotropy

What do we expect for the large angular scales of the CMB? A crucial ingredient of cosmology's concordance model is cosmological inflation | a period of accelerating cosmic expansion in the early universe. If we assume that inflationary expansion persisted for sufficiently many e-folds, then we expect to live in a homogeneous and isotropic universe within a domain larger than our Hubble volume. This homogeneity and isotropy will not be exact, but should characterize both the background and the statistical distributions of matter and metric fluctuations around that background. These fluctuations are made visible as anisotropies of the CMB temperature and polarization, which are expected to inherit the underlying statistical isotropy. The temperature T seen in direction ^ e is predicted to be described by a Gaussian random field on the sky (i.e. the 2-sphere S2), which implies that we can expand it in terms of spherical harmonics Y`m(^ e) multiplied by independent Gaussian random coefficients a`m of zero mean.

Statistical isotropy implies that the expectation values of all n-point correlation functions (of the temperature or polarization) are invariant under arbitrary rotations of the sky. .....

D. Cosmic variance

As we can measure only one sky…Let us for the moment assume that we are able to measure the primordial CMB of the full sky, without any instrumental noise. …. the variance of the monopole cannot be defined and **the measured dipole is dominated by our motion through the universe**, rather than by primordial physics. (Separation of the Doppler dipole from the intrinsic dipole is possible in principle [12, 13], but not with existing data.)

III. ALIGNMENTS

…. The twin assumptions of statistical isotropy and Gaussianity are the starting point of any CMB analysis. The measurements of the CMB monopole, dipole and (T)rms tell us that isotropy is observationally established at the per cent level without any cosmological assumption, and at a level 10^{-4} if we attribute the dominant contribution

to the dipole to our peculiar motion. ...
Let us assume that the various methods that have been developed to get rid of the Galactic foreground in single frequency band maps of the microwave sky are reliable
Our review of alignments will be based on the internal linear combination (ILC) map produced by the WMAP team, which is based on a minimal variance combination of the WMAP frequency bands.
While the multipole vectors contain all information about the directionality
of the CMB temperature pattern, they are not simply related to the hot and cold spots and, for example, do not correspond to the temperature minima/maxima [14]. Notice that l = 2 and 3 temperature patterns are rather planar with the same plane, and that their vectors lie approximately in this plane. A. Multipole vectors
The multipole vectors
contain information about the \directions" associated
Note that we call each ^ v(`; i) a multipole vector
but it is only defined up to a sign. ... these vectors actually are headless. Regardless, we will continue to refer to them as multipole vectors and not use the overall sign of the vector in our analysis. .... multipole
vectors were actually first used by Maxwell [20] more than 100 years ago in his study of multipole moments in electrodynamics. ....
The relation between multipole vectors and the usual harmonic basis is very much the same as that between Cartesian and spherical coordinates of standard geometry: both are complete bases, but specific problems are much more easily addressed in one basis than the other.
In particular, we and others have found that **multipole vectors are particularly well suited for tests of planarity and alignment of the CMB anisotropy pattern**. ...
B. Planarity and Alignments
Tegmark et al. [22] and de Oliveira-Costa et al. [23] rst argued that the octopole is planar and that the quadrupole and octopole planes are aligned.
The quadrupole is fully described
by two multipole vectors, which define a plane.
(Note that the oriented area vector does not fully characterize the quadrupole, as pairs of quadrupole multipole vectors related by a rotation about the oriented area vector lead to the same oriented area vector.) The octopole is defined by three multipole vectors which determine (but again are not fully determined by) three area vectors. -

….. Note that three out of four normals lie very
close to the dipole direction. The probability of this alignment being accidental is about one part in a thousand. Moreover, the ecliptic plane traces out a locus of zero of the combined quadrupole and octopole over a broad swath of the sky | neatly separating a hot spot in the northern sky from a cold spot in the south. **These apparent correlations with the solar system geometry are puzzling and currently unexplained.**

Hence there are a total of four planes determined by the quadrupole and octopole.
…the four area vectors of the quadrupole and octopole are mutually close (i.e. the quadrupole and octopole planes are aligned) at the 99:6% C.L.;
the quadrupole and octopole planes are orthogonal to the ecliptic at the 95:9% C.L.; this alignment was at 98:5% C.L. in our analysis of the WMAP 1 year maps. The reduction of alignment was due to WMAP's adaption of a new radiometer gain model for the 3 year data analysis, that took seasonal variations of the receiver box temperature into account | a systematic that is indeed correlated with the ecliptic plane. **We regard that as clear evidence that multipole vectors are a sensitive probe of alignments**;
the normals to these four planes are aligned with the direction of the cosmological dipole (and with the equinoxes) at a level inconsistent with Gaussian random, statistically isotropic skies at 99:7% C.L.;
the ecliptic threads between a hot and a cold spot of the combined quadrupole and octopole map, following a node line across about 1/3 of the sky and separating the three strong extrema from the three weak extrema of the map; this is unlikely at about the 95% C.L.
These numbers refer to the WMAP ILC map from three years of data; other maps give similar results. Moreover, **correction for the kinematic quadrupole { slight modi - cation of the quadrupole due to our motion through the CMB rest frame { must be made and increases signi - cance of the alignments**.
While not all of these alignments are statistically independent, their combined statistical significance is certainly greater than their individual significances. For example, given their mutual alignments, the conditional probability of the four normals lying so close to the ecliptic, is less than 2%; the combined probability of the four

normals being both so aligned with each other and so
close to the ecliptic is less than 0.4% x 2% = 0:008%.
These are therefore clearly surprising, highly statistically significant anomalies | unexpected in the standard infl ationary theory and the accepted cosmological model.
Particularly puzzling are the alignments with solar system features. CMB anisotropy should clearly not be correlated with our local habitat. … there is no obvious way to explain the observed correlations. Moreover, if their explanation is that they are a foreground, then that will likely exacerbate other anomalies ….
Our studies (see [14]) indicate that the observed alignments are with the ecliptic plane, with the equinox or with the CMB dipole, **and not with the Galactic plane:** the alignments of the quadrupole and octopole planes with the equinox/ecliptic/dipole directions are much more significant than those for the Galactic plane.
Moreover**, it is remarkably curious that it is precisely the ecliptic alignment that has been found on somewhat smaller scales using the power spectrum analyses of statistical isotropy** [26{29].
……]. Because l = 2; 3 are both planar (the quadrupole trivially so, the octopole because the three planes of the octopole are nearly parallel), the direction that maximizes the angular momentum dispersion of each is nearly the same as the (average) direction of that multipole's planes.
To test alignments of multipole planes with physical directions, we find the plane whose normal, ^ n, has the largest dot product with the sum of the four quadrupole and octopole area vectors [14]. Again, since ~ wi ^ n is defined only up to a sign, we take the absolute value of each dot product.
C. Summary
…. We have shown that the alignment of the quadrupole and octopole planes is inconsistent with Gaussian, statistically isotropic skies at least at the 99% confidence level. Further a number of (possibly related) alignments occur at 95% confidence levels or greater. Put together these provide **a strong indication that the full sky CMB WMAP maps are inconsistent with the standard cosmological model at large angles**. **Even more peculiar is the alignment of the quadrupole and octopole with solar system features (the ecliptic plane and the dipole).**
This is strongly suggestive of an unknown systematic in

the data reduction; however, careful scrutiny has revealed no such systematic...

We again stress that these results hold for full sky maps; maps that are produced through combination of the individual frequency maps in such a way as to remove foregrounds..

IV. TWO-POINT ANGULAR CORRELATION FUNCTION

The usual CMB analysis solely involves the spherical harmonic decomposition and the two-point angular power spectrum. There are many reasons for this. Firstly, when working with a statistically isotropic universe the angular power spectrum contains all of the physical information. Secondly, the standard theory predicts the a`m and their statistical properties.., thus the spherical harmonic basis is a natural one to employ. Finally, as measured today the angular size of the horizon at the time of last scattering is approximately 1 degree. Since theta(deg) = 200/l the causal physics at the surface of last scattering leaves its imprint on the CMB on small scales, theta < 1 or l > 100. The two-point angular power spectrum focuses on these small scales, making it a good means of exploring the physics of the last scattering surface.

The two-point angular correlation function provides another means of analyzing CMB observations and should not be ignored even if, in principle, it contains the same information as the angular power spectrum. Thus, even in the case of full sky observations and/or statistical isotropy there are bene ts in looking at the data in di erent ways. The situation is similar to a function in one dimension where it is widely appreciated that features easily found in the real space analysis can be very di cult to nd in the Fourier transform, and vice versa. Furthermore, the two-point angular correlation function highlights behavior at large angles (small l); the opposite of the two-point angular power spectrum. Thus the angular correlation function allows for easier study of the temperature fluctuation modes that are super-horizon sized at the time of last scattering. Finally, the angular correlation function in its simplest form is a direct pixel based measure (see below). Thus it does not rely on the reconstruction of contaminated regions of the sky to employ.

This makes it a simple, robust measure even for partial sky coverage.

A. Definition

….. we average over the sky so that what we mean by the two-point angular correlation function is a sky average,

B. Missing angular power at large scales
Spergel et al. [2] found that the two-point correlation function nearly vanishes on scales greater than about 60 degrees, contrary to what the standard CDM theory predicts, and in agreement with the same finding obtained from COBE data about a decade earlier [32].
....
Meanwhile the full-sky ILC C( ) and the Legendre transform of the maximum likelihood estimator (MLE) of the C` agree well with each other, but not with any of the others.
The most striking feature of the cut-sky (and pseudo-C`) C( ), is that all of them are very nearly zero above about 60 deg, except for some anticorrelation near 180 deg . This is also true for the fullsky curves, but less so.
FIG. 5.
... Even by eye, it is apparent that masked maps have C( ) that is consistent with zero at theta > 60 deg.
... we see that almost all of the contribution to the full sky two-point angular correlation function comes from correlations with at least one point inside the masked region. Conversely, there is essentially no large-angle correlation for points outside the masked region and even very little among the points completely inside the mask. We also see that all the curves cross zero at nearly the same angle, 90 deg.
We have no explanation for these results though they may point to systematics in the data.
.... the pixel-based two-point correlation function on the region of the sky outside a conservative galactic mask is inconsistent with the predictions of the standard CDM model for the identical pixel-based two-point correlation function on the identically masked sky.
The striking feature of the two-point angular correlation function as seen in Fig. 5 is not that it disagrees with CDM (though it does at > 90% C.L.) but that at large angles it is nearly zero. This lack of large angle correlations is unexpected in infl ationary models. The S1=2 statistic shows a discrepancy exists at more than 99:9% C.L. ...
This surprising lack of large angle correlation outside the masked region remains an open problem.
.... it is really a range of low multipoles that conspire to make up the vanishing C( ). .... It is this conspiracy

that is most disturbing, since it violates the independence
of the Cl of different l that defines statistical isotropy.
….. a Gaussian
random, statistically isotropic realization is unlikely to
produce the observed lack of large angle correlations at
the 97% C.L. ….either (i) the low-` C` are correlated, contrary to the
assumption of statistical isotropy1 or (ii) our Universe is
an extremely unlikely realization of whatever statistically
isotropic model one devises.
It is for this reason that theoretical efforts to explain
\low power on large scales" must focus on explaining the
low C( ) at theta > 60 deg, rather than the low quadrupole.
…. low power and alignments are uncorrelated | i.e. that having one
does not imply a larger or smaller probability of having
the other….. one
might view the 99:6% C.L. of quadrupole-octopole alignment
presented in the previous section and the 95% C.L.
for lack of correlation in full-sky maps reported in this
section as statistically independent.
V. QUEST FOR AN EXPLANATION
Understanding the origin of CMB anomalies is clearly
important. Both the observed alignments of the low-`
full-sky multipoles, and the absence of large-angle correlations
(especially on the galaxy-cut sky) are severely inconsistent
with predictions of standard cosmological theory.
A. Additive vs. multiplicative e ects
Most explanations work by adding power to the
large-angle CMB, while the observed anisotropies
actually have less large-scale power, and particularly
less large angle correlation, than the CDM
cosmological model predicts.
**Unaccounted for sources of CMB fluctuations in
the foreground, even if possessing/causing aligned
low-l multipoles of their own, cannot bring unaligned
statistically isotropic cosmological perturbations
into alignment**..
The alignments of the quadrupole and octopole are
with respect to the ecliptic plane and near the
dipole direction. It is generally difficult to have
these directions naturally be picked out by any class
of explanations
…. additive modulations
of the CMB sky that ameliorate the alignment
problems tend to worsen the overall likelihood at large
scales … ….
the observed

quadrupole and octopole as seen in the preferred (dipole)
frame are dominated by the m = l components.

B. Astrophysical explanations

One fairly obvious possibility is that there is a pernicious foreground that contaminates the primordial CMB and leads to the observed anomalies. But most such foregrounds are Galactic, while the observed alignments are with respect to the ecliptic plane. One would expect that Galactic foregrounds should lead to Galactic and not ecliptic foregrounds.

..we showed that, by artificially adding a large admixture of Galactic foregrounds to WMAP CMB maps, the quadrupole vectors move near the z-axis and the normal into the Galactic plane, while for the octopole all three normals become close to the Galactic disk at 90 from the Galactic center. Therefore, as expected Galactic foregrounds lead to Galactic, and not ecliptic, correlations of the quadrupole and octopole .

Moreover, in [14], we have shown that the known Galactic foregrounds possess a multipole vector structure very different from that of the observed quadrupole and octopole. The quadrupole is nearly pure Y22 in the frame where the z-axis is parallel to the dipole or any nearly equivalent direction), while the octopole is dominantly Y33 in the same frame.

Mechanisms which produce an alteration of the microwave signal from a relatively small patch of sky | and all of the recent proposals fall into this class | are most likely to produce aligned Y20 and Y30. This is essentially because the low-l multipole vectors will all be parallel to each other, leading to a Yl0 in this frame.

A number of authors have attempted to explain the observed quadrupole-octopole correlations in terms of a new foreground | for example the Rees-Sciama effect , interstellar dust , local voids [53], or the Sunyaev-Zeldovich effect [54]. Most if not all of these proposals have a diffcult time explaining the anomalies without severe fine tuning.

Dikarev et al. [57, 58] studied the question of whether solar system dust could give rise to sizable levels of microwave emission or absorption. Surprisingly, very little is known about dust grains of mm to cm size in the Solar system, and their absorption/emission properties strongly depend on their chemical composition.

… carboneous and silicate dust grains might contribute up to a few Kdeg close to the ecliptic plane, e.g. due to the trans-Neptunian object

belt. Such an extra contribution along the ecliptic
could give rise to CMB structures aligned with the
ecliptic, but those would look very different from the observed
ones. On top of that, Solar system dust would
be a new additive foreground and could not explain the
lack of large angle correlations. Thus it seems unlikely
that Solar system dust grains cause the reported large angle
anomalies….
…. the anomalies may not reflect an unknown foreground that has been
neglected,
but rather the \mis-subtraction" of a known foreground.
However, it has never quite been clear to us how this
leads to the observed alignments or lack or large angle
correlations, and we are unaware of any literature that
realizes this suggestion successfully.
C. Data analysis explanations
Most of the results discussed so far have been obtained
using reconstructed full-sky maps of the WMAP observations
**In the presence of the sky cut of
even just a few degrees, the errors in the reconstructed
anisotropy pattern, and the directions of multipole vectors,
are too large to allow drawing quantitative conclusions
about the observed alignments [15**]. These large
errors are expected: while the power in the CMB (represented,
say, by the angular power spectrum Cl) can be
accurately recovered since there are 2l+1 modes available
for each l, there are only 2 modes available for each multipole
vector; hence the cut-sky reconstruction is noisier.
However the cut-sky alignment probabilities, while very
uncertain, are consistent with the full-sky values [14, 50];
more generally, **the alignments appear to be rather robust
to Galactic cuts and foreground contamination [60**].
… Efstathiou … argued that maximum likelihood
estimators can be applied to the cut-sky maps to
reliably and optimally reconstruct the CMB anisotropy
of the whole sky; …..However, quantities
calculated on the cut sky are clearly insensitive to
assumptions about what lies behind the cut. We can
only observe reliably the 75% of the sky that was
not masked, and that is where the large-angle two-pointcorrelation
is near-vanishing. Any attempt to reconstruct
the full sky must make assumptions about the statistical
properties of the CMB sky, and would clearly be affected
by the coupling of small-scale and large-scale modes |
D. Instrumental explanations
… WMAP avoids making

observations near the Sun, therefore covering regions away from the ecliptic more than those near the ecliptic. .. the corresponding variations in the noise per pixel …could, in principle, be amplified and create the observed ecliptic anomalies. However a successful proposal for such an amplification has not yet been put forward.

Another possibility is that an imperfect instrument couples with dominant signals from the sky to create anomalies.

As an aside, note that this type of explanation needs to assume that the higher multipoles are not aligned with the dipole/ecliptic, and moreover, requires essentially no intrinsic power at large scales (that is, even less than what is observed).

To summarize: even though the ecliptic alignments (and the north-south power asymmetry) hint at a systematic effect due to some kind of coupling of an observational strategy and the instrument, to date no plausible proposal of this sort has been put forth.

E. Cosmological Explanations

The most exciting possibility is that the observed anomalies have primordial origin, and potentially inform us about the conditions in the early universe. One expects that in this case the alignments with the dipole, or with the solar system, would be statistical flukes.

… However, outside of explaining the anomalies, the motivation for these anisotropic models is not compelling and they seem somewhat contrived…. Nevertheless, given the large-scale CMB observations, as well as the lack of fundamental theory that would explain inflation, investigating such models is well worthwhile.

A very reasonable approach is to describe breaking of the isotropy with a phenomenological model, measure the parameters of the model, and then try to draw inferences about the underlying physical mechanism. …

As with the other attempts to explain the anomalies, we conclude that, while there have been some interesting and even promising suggestions**, no cosmological explanation to date has been compelling.**

VI. EXPLANATIONS FROM THE WMAP TEAM

re | the alignment of low multipoles with each other | the WMAP team agrees that the alignment is observed and argue, based on work by Francis and Peacock

[86], that the integrated Sachs-Wolfe (ISW) contribution of structures at small redshifts (z 1) could be held responsible. There are serious problems with this argument. Firstly, the ordinary Sachs-Wolfe (SW) effect typically dominates at these l over the ISW. Thus, only if the ordinary SW effect on the last scattering surface is anomalously low will the ISW contribution dominate. Secondly, though the ISW may lead to alignment of the quadrupole and octopole it is not an explanation for the observed Solar system alignments. This alignment would need to be an additional statistical fluke. Finally, this explanation does nothing whatsoever to mitigate the lack of large scale angular correlation because the ISW effect acts as an additive component and should be statistically uncorrelated from the primordial CMB. Therefore, even if the ISW reconstruction is taken as reliable, this argument would imply;

1. an accidental downward fluctuation of the SW sufficient for the ISW of local structure to dominate and cause an alignment, and
2. an accidental cancellation in angular correlation between the SW and ISW temperature patterns.

Neither the WMAP team nor Francis and Peacock estimate the likelihood of these two newly created puzzles.

Re | the lack of angular correlation | Efstathiou, Ma and Hanson [35 argue that quadratic estimators are better estimates of the full sky from cut-sky data and are in better agreement with the concordance model. While these estimators have been shown to be optimal under the assumption of statistical isotropy, it is unclear why they should be employed when this assumption is to be tested.

.. arguments from the WMAP team offer neither new nor convincing explanations of the observed anomalies discussed in this review. At best they replace one set of anomalies for another.

VII. CONCLUSIONS

The CMB is widely regarded as offering strong substantiating evidence for the concordance model of cosmology. Indeed the agreement between theory and data is remarkable | the patterns in the two point correlation functions (TT, TE and EE) of Doppler peaks and troughs are reproduced in detail by fitting with only six (or so) cosmological parameters. This agreement should not be taken lightly; it shows our precise understanding of the causal physics on the last scattering surface. Even

so, **the cosmological model we arrive at is baroque,** requiring
the introduction at different scales and epochs
of three sources of energy density that are only detected
gravitationally | dark matter, dark energy and the infl
aton. This alone should encourage us to continuously
challenge the model and probe the observations particularly
on scales larger than the horizon at the time of last
scattering.
At the very least, probes of the large-angle (low-l)
properties of the CMB reveal that we do not live in a
typical realization of the concordance model of inflationary
CDM. We have reviewed a number of the ways in
which that is true: the peculiar geometry of the l = 2
and 3 multipoles | their planarity, their mutual alignment,
their alignment perpendicular to the ecliptic and
to the dipole; the north-south asymmetry; and the near
absence of two-point correlations for points separated by
more than 60^{o} .
If indeed the observed l = 2 and 3 CMB fluctuations
are not cosmological, one must reconsider all CMB results
that rely on the low l, e.g. the measurement of
the optical depth from CMB polarization at low l or the
spectral index of scalar perturbations and its running.
Moreover, the CMB-galaxy cross-correlation, which has
been used to provide evidence for the Integrated Sachs Wolfe
effect and hence the existence of dark energy, also
gets contributions from the lowest multipoles . Indeed, **it is quite possible that the underlying**
physical mechanism does not cut off abruptly at the octopole,
but rather affects the higher multipoles. Indeed,
several pieces of evidence have been presented for **anomalies**
at l > 3 (e.g. [87, 88]). One of these is the parity of
the microwave sky. While the observational fact that
the octopole is larger than the quadrupole (C3 > C2) is
not remarkable on its own, including higher multipoles
(up to l= 20) the microwave sky appears to be parity
odd at a statistically significant . **It is hard to imagine a cosmological explanation**
for a parity odd universe, but the same holds
true for unidentified systematics or unaccounted astrophysical
foregrounds, especially as this recently noticed
puzzle shows up in the very well studied angular power spectrum.

[58] Planck Collaboration, *Planck Intermediate Results, XIII. Constraints on peculiar velocities,* arXiv: 1303.5090v3 ……….uses LCDM..

[59] http://en.wikipedia.org/wiki/Tests_of_general_relativity andhttp://en.wikipedia.org/wiki/Tests_of_special_relativity

Fails general covariance….

Fails Wang FOC test…

[63] Alnes and Amarzguioui, *CMB anisotropies seen by an off-center observer in a spherically symmetric inhomogeneous universe,* arXiv:astr-ph/0607334v2

inhomogeneous, but spherically symmetric universe models containing only matter can yield a very good fit to the SNIa data and the position of the first CMB peak. In this work we examine how far away from the center of inhomogeneity the observer can be located in these models and still fit the data well. Furthermore, we investigate whether such an off-center location can explain the observed alignment of the lowest multipoles of the CMB map. We find that the observer has to be located within a radius of ∼ 15 Mpc from the center for the induced dipole to be less than that observed by the COBE satellite. But for such small displacements from the center, the induced quadru- and octopoles turn out to be insufficiently large to explain the alignment.

we studied spherically symmetric inhomogeneous universe models – the so-called LemaˆıtreTolman-Bondi (LTB) models. We found that for a certain class of inhomogeneities, such models could easily explain various cosmological observations without introducing dark energy, most notably the luminosity distanceredshift relation of type IA supernovae and the position of the first peak in the CMB spectrum. The inhomogeneities required are of the form of a spherically symmetric underdense bubble in an otherwise flat and homogeneous Einstein-de Sitter universe, with the observer located at the center of the bubble. Unless the observer is positioned exactly at the center of the bubble, the distribution of matter, as seen by the observer, will be anisotropic. This will affect the observed microwave background and constrain the possible location of the observer, since the CMB dipole must be in agreement with observations [2]. Note that in a homogeneous universe model, this dipole is attributed to the peculiar velocity of the observer. However, as discussed in [3], in an LTB model there will be an additional contribution to the dipole from the anisotropy of space-time. Thus, the dipole seen by an off-center observer will be due to a combination of kinematic effects and the off-center location. The anisotropy will also induce higher multipoles in the CMB spectrum. Moffat [4] proposes this mechanism as possible explanation for the observed alignment of the CMB quadru- and octopole [5, 6, 7, 8, 9], since the direction from the observer towards the center of the bubble singles out a "special" axis. In this work we will investigate these induced anisotropies in the CMB to establish how far from the center the observer can be located, and whether they can offer an explanation to the alignment of the lowest multipoles. ..

…III. TEMPERATURE ANISOTROPIES We wish to examine how being situated away from the center of the LTB coordinate system affects the CMB temperature measured by the observer. Since space-time is no longer spherically symmetric around such an observer, we expect him to measure additional anisotropies in the temperature to those measured by an observer at the center. In this paper we concentrate on the additional anisotropies rising from the observer's location, i.e. we disregard any intrinsic anisotropies in the CMB temperature at the last-scattering surface. Thus, we assume the temperature at the last-scattering surface to be isotropic. Any anisotropies measured by observers today are therefore due to the propagation of photons through an anisotropic space-time…

…The observed dipole in the CMB is of the order $|a10| \sim 10{-}3$. This will put a natural constraint on how far away from the origin the observer can be located, since a farther off-center position usually means a larger dipole.

…In our previous work [1], we assumed that the observer was positioned at the center of the bubble, and found a model that gave a good agreement with the Hubble diagram of observed SNIa and the position of the first CMB peak

…As discussed in the previous section, an off-center observer will measure a temperature anisotropy due to the non-symmetric paths traversed by CMB photons in different direction in the sky. Using Eqs. (26) and (27), r cosθ r sinθ r cosθ r sinθ …..we can now calculate the temperature multipoles seen by such an observer. As an example, a plot of the multipoles can be seen in Fig. 5 for an observer who is located 200 Mpc from the center in model I.

….In Fig. 6, the coefficients al0 for the dipole (l = 1), quadrupole (l = 2) and octopole (l = 3) are plotted as functions of the observer's position in model I. The most striking feature of these plots is that the quadruand octopoles are very small compared to the dipole. If we assume that the induced dipole must be smaller than 10−3 , the induced quadrupole is less than 10−7 while the induced octopole is smaller than 10−9 .

…The main purpose of this paper has been to determine the maximum displacement of the observer from the origin of the underdensity, for which the induced CMB dipole remains in agreement with the results observed by COBE [2]. Of course, one could in principle introduce an additional peculiar velocity towards the center of the underdensity to compensate for a too large induced dipole, but such a coincidence would be very difficult to justify. Therefore, we must require the induced a10 to be of order 10−3 or less, which from the plots in Figs. 6 and 7 can be translated to dobs . 15 Mpc . (30) where d is the physical distance. When compared to the size of the underdensity, which according to Fig. 2 is around 1 500Mpc, this means that if we are placed at a random position inside the bubble, there is roughly a chance of 1 to 106 that we end up inside the region allowed by Eq. (30). This is a rather strong violation of the Copernican principle, which states that we are not situated at a special place in the universe. On the other hand, a 10^{-6} probability is still much better than the infinitely improbable case of the observer being exactly at the center of the underdensity. Note that the size of the underdensity is dictated by the fit to the CMB and SNIa data. We have not been able to find smaller bubbles that fit these data as well as the models considered here.

…From Figs. 6 and 7 we see that the induced multipoles become larger the farther away from the origin the observer is located, as we would expect. Thus, the largest possible quadru- and octopoles with a dipole compatible with COBE measurements are those for an observer about 15 Mpc from the origin. However, at this relatively small distance, the values for these are of the order 10^{-7} for the quadrupole, and 10^{-9} for the octopole. It is therefore clear that the induced quadru- and octopole cannot explain the observed alignment of the low-l multipoles in the CMB, since their contributions are negligible compared to the observed anisotropies (which are of order 10^{-5}). Furthermore, any off-center placement must necessarily result in axial symmetric contributions to the CMB spectrum. Even if such contributions were of the correct order, Raki´c et al. [16] show that they are very unlikely to explain the alignment.

….Eqs. (37)-(39) imply that it is impossible to obtain sufficiently large values for the quadru- and octopole as long as the dipole is within the limits set by the COBE data.

…..In our analysis so far we have only considered contributions to the multipoles from the off-center placement. There will of course be additional contributions from various sources such as the intrinsic primordial temperature anisotropies, the integrated Sachs-Wolfe (ISW) effect [19] and a non-vanishing peculiar velocity of the observer. We have seen that when the dipole is constrained by data, the quadru- and octopoles due to the off-center placement are considerably weaker than those observed in the CMB. A possible way to obtain stronger quadru- and dipoles is to place the observer farther away from the center, while allowing one or more of the effects mentioned above to cancel out the excessive contribution to the dipole. However, concerning the first two effects, it is clear that neither of these can achieve such cancellation. Although there is no way of measuring directly the intrinsic dipole, it is reasonable to assume that it is of the same order as the neighboring multipoles, which are of order 10^{-5} Similarly, we expect the contribution to the dipole from the ISW effect to be of the same order as for the quadru- and octopole. Therefore, it is very unlikely that these effects are responsible for a chance cancellation of an excessive contribution to the dipole from the off-center placement. A non-vanishing peculiar velocity can reduce the dipole to any desired value as long as the velocity is chosen large enough. However, multipoles due to such motion will have a hierarchical scaling similar to that which we showed in the Newtonian case. Thus, even if we manage to obtain values for the dipole and quadrupole of the correct order, the octopole would still be too weak. From this we can conclude that even when combined with other effects, the off-center placement cannot provide sufficient power to both the quadru- and octopole. In summary, LTB models like the ones listed in Table I are not ruled out on the basis of these results, but they do require a violation of the Copernican principle, since the observer would have to be located at a very special place. The volume within which the observer can be located is severely constrained by the size of the dipole induced by an off-center placement of the observer. As a consequence of this, the quadru- and octopole turn out to have insufficient power to explain the observed alignment.

[64] Moffat J W, *Cosmic Microwave Background, Accelerating Universe and Inhomogeneous Cosmology,* arXiv:astro-ph/0502110v6
Based on FLRW

[65] Bellido and Haugbølle, *Looking the void in the eyes – the kSZ effect in LTB models,*arXiv:0807.1326v1
As an alternative explanation of the dimming of distant supernovae it has recently been advocated that we live in a special place in the Universe near the centre of a large void described by a Lemaitre-Tolman-Bondi (LTB) metric. The Universe is no longer homogeneous and isotropic and the apparent late time acceleration is actually a consequence of spatial gradients in the metric. If we did not live close to the centre of the void, we would have observed a Cosmic Microwave Background (CMB) dipole much larger than that allowed by observations. Hence, until now it has been argued, for the model to be consistent with observations, that by coincidence we happen to live very close to the centre of the void or we are moving towards it. However, even if we are at the centre of the void, we can observe distant galaxy clusters, which are off-centre. In their frame of reference there should be a large CMB dipole, which manifests itself observationally for us as a kinematic Sunyaev-Zeldovich (kSZ) effect. ….. We show that current observations of only 9 clusters with large error bars already rule out LTB models with void sizes greater than approximately 1.5 Gpc and a significant underdensity, …. if the LTB model is confirmed by observations, a kSZ survey gives a unique possibility of directly reconstructing the expansion rate and underdensity profile of the void.
Based on GR
[66] Alnes, Amarzgiuoui and Grøn, *An inhomogeneous alternative to dark energy?,*arXiv:astro-ph/0512006v2
Based on LTB

[76] See for example: Rubart and Schwarz, *Cosmic radio dipole from NVSS and WENSS,*arXiv:1301.5559v3

[77] Tiwari et al, *Dipole anisotropy in sky brightness and source count distribution in radio NVSS data*, arXiv:1307.1947v3
[78] Ghosh S, *Generating Intrinsic Dipole Anisotropy in the Large Scale Structures*, arXiv:1309.6547
[79] Rubart, Bacon and Schwarz, *Impact of local structure on the cosmic radio dipole,*arXiv:1402.0376
[80] Shurtleff R, *A Large Scale Pattern from Optical Quasar Polarization Vectors*, arXiv:1311.6118v1
[81] Hawkins, Maddox and Merrifield, *No Periodicities in 2dF Redshift Survey Data,arXiv:*astro-ph/*0208117v1*
[82] Bajan et al, *On the investigations of galaxy redshift periodicity*, arXiv:astro-ph/0606294
[83] The SDSS III BOSS webpage: http://www.sdss3.org/surveys/boss.php
[84] Anderson et al, *The clustering of galaxies in the SDSS-III Baryon Oscillation Spectroscopic Survey: Baryon Acoustic Oscillations in the Data Release 10 and 11 Galaxy Samples,* arXiv:1312.4877v1
[85] Hartnett and Hirano, *Galaxy redshift abundance periodicity from Fourier analysis of number counts N(z) using SDSS and 2dF GRS galaxy surveys*, arXiv:0711.4885v3
[86] Hartnett and Hirano plotted galaxy density as a pure function of redshift, rather than as a function of distance as is more commonly done
[87] Hirano and Komiya, *Observational tests for oscillating expansion rate of the Universe,* arXiv:1008.4456v2
[88] Bell and Comeau, *More Evidence for an Oscillation Superimposed on the Hubble Flow*, arXiv:1308.2624
[89] http://dealingwithcreationisminastronomy.blogspot.co.uk/2008/09/john-hartnetts-cosmos-1-introduction.html
[90] Hartnett J G, *Unknown selection effect simulates redshift periodicity in quasar number counts from Sloan Digital Sky Survey*, arXiv:0712.3833v3
[91] http://adsabs.harvard.edu/abs/2009ASPC..413…77H
[92] http://johnhartnett.org/2014/05/26/our-galaxy-near-the-centre-of-concentric-spherical-shells-of-galaxies/

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End Notes:

[1] See for example http://galileowaswrong.com/

[2] http://www.theprinciplemovie.com/ andhttps://www.facebook.com/theprinciplemovie

[3] Here Comes the Sun, http://www.geocentrismdebunked.org/wp-content/uploads/2014/04/Here-Comes-the-Sun-Alec-MacAndrew.pdf

[4] The other major cosmological theory was the Steady State model supported by Fred Hoyle, Hermann Bondi, Thomas Gold and others. It did not predict and cannot explain the black body spectrum of the CMB, and so it has fallen away.

[5] The theory underpinning the behaviour of electrons and their interaction with light, Quantum Electrodynamics or QED, is the most precisely predictive theory in physics

[6] Zel'dovich, YB, *A hypothesis, unifying the structure and the entropy of the Universe,*Monthly Notices of the Royal Astronomical Society, Vol. 160, p. 1P (1972)

[7] There are two effects in play here: the photons in more dense regions are intrinsically hotter, but GR predicts that they are cooled as they climb out of the deeper gravity potential well of the higher density. The latter effect wins: it is 50% larger than the intrinsic effect as we perceive it. The result is that the cumulative temperature fluctuation is 1/3 that predicted by the gravitational effect alone

[8] For those of a technical and mathematical bent, unlike the discrete Fourier transform, which decomposes the signal into a series of sinusoids, the spherical harmonics of the CMB are a series of Legendre polynomials.

[9] For a mathematical treatment of this theory go to Ned Wright's cosmology primer:http://ned.ipac.caltech.edu/level5/Sept02/Reid/Reid5_2.html

[10] The COBE scientific papers are here:http://aether.lbl.gov/www/projects/cobe/papers.html

[11] The huge set of technical WMAP papers can be found here:http://lambda.gsfc.nasa.gov/product/map/current/map_bibliography.cfm

[12] The ESA Planck mission reports here: http://www.sciops.esa.int/index.php?project=PLANCK&page=Planck_Published_Papers

[13] http://cmb.phys.cwru.edu/boomerang/
[14] http://cosmology.berkeley.edu/group/cmb/
[15] Planck Collaboration, *Planck 2013 results. I. Overview of products and scientific results* arXiv:1303.5062v1
[16] Big Bang Nucleosynthesis is the theory that predicts the relative abundance of the nuclei of hydrogen, helium and lithium, the light elements, in the early and current Universe
[17] There is also a third problem of quantum field theory solved by inflation – the prediction of magnetic monopoles, which have, so far, not been observed.
[18] Guth A H, *"The Inflationary Universe: A Possible Solution to the Horizon and Flatness Problems"*. Physical Review **D23**: 347 (1981)
[19] Adiabatic perturbations are those where the matter and energy fluctuations are in phase – in other words, the fluctuations would be in thermal equilibrium.
[20] Zwicky, F*, Die Rotverschiebung von extragalaktischen Nebeln*, Helvetica Physica Acta, Vol. 6, p. 110-127 (1933)
[21] See for example: Rubin et al, *Rotation Velocities of 16 Sa Galaxies and a Comparison of Sa, Sb, and Sc Rotation Properties,* Astrophys J 289, 81, (1980)
[22] The Baryon Acoustic Oscillation theory explains quantitatively why the distribution of dark matter in galaxies is different from the distribution of ordinary matter such as stars.
[23] Type 1a supernovae are white dwarf stars that accrete matter up to a certain critical mass known as the Chandrasekhar limit. At this point the star collapses and carbon fusion of most of the mass of the star takes place within a few seconds, blowing the star apart and releasing an enormous quantity of energy.
[24] Riess A et al. (Supernova Search Team) (1998). "*Observational evidence from supernovae for an accelerating universe and a cosmological constant*". Astronomical J.**116** (3): 1009–38. arXiv:astro-ph/9805201
[25] Perlmutter S et al. (The Supernova Cosmology Project) (1999). "*Measurements of Omega and Lambda from 42 high redshift supernovae*". Astrophysical Journal **517** (2): 565–86. arXiv:astro-ph/9812133
[26] The 2dF Galaxy Redshift Survey

[27] Sherwin et al, *Evidence for dark energy from the cosmic microwave background alone using the Atacama Cosmology Telescope lensing measurements*, arXiv:1105.0419v3
[28] The measurement of the CMB is not all down to WMAP and Planck: see for example Sievers et al, *The Atacama Cosmology Telescope: Cosmological parameters from three seasons of data*, arXiv 1301.0824v3
[29] Planck Collaboration, *Planck 2013 Results. XXIII. Isotropy and statistics of the CMB*, arXiv:1303.5083v3

[30] Ibid, Sec 5.2
[31] Planck Collaboration, *Planck 2013. Results. XXVII. Doppler Boosting of the CMB: Eppur si muove,* arXiv:1303.5087 where additional effects in the CMB (increased power in the anisotropies in the direction of travel and CMB aberration) are strong evidence that the dipole is caused by motion of the solar system relative to the CMB rest frame.
[32] Planck Collaboration, *Planck 2013 Results. XXIII. Isotropy and statistics of the CMB*, arXiv:1303.5083v3, Sec 5.3
[33] Ibid Sec 5.5
[34] Ibid Sec 5.8
[35] Ibid Sec 5.9
[36] See for example: Vielva, *A Comprehensive Review of the Cold Spot*, arXiv:1008.3051
[37] Bennett et al, *Nine-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Final Maps and Results,* arXiv:1212.5225
[38] Copi et al, *Alignments from WMAP and Planck,* arXiv:1311.4562v2

[39] Bennett et al, *Seven Year WMAP Observations:Are there Cosmic Microwave Background Anomalies?*, arXiv:1001.4758
Uses LCDM

[40] Copi et al, *Large-Angle Anomalies in the CMB*, arXiv:1004.5602v2

[41] The Bianchi solutions to the Einstein field equations are homogeneous but anisotropic (unlike the Standard Model which is based on the homogeneous and isotropic FLRW solution). In particular, a Bianchi Type VIIh template, which describes an anisotropic rotating Universe, can

explain the anomalies, but the cosmology is unphysical – its basic parameters fail to match known cosmological data. The effect of a different kind of universe metric, one that is not homogeneous and isotropic (unlike the Standard Model), is overlaid on the underlying FLRW metric and adjusted to remove the anomalies. Such a procedure is possible, and although it reduces or eliminates the anomalies, it makes predictions that fail to match significant measured aspects of the universe.

[42] Rath et al, *Direction dependence of the power spectrum and its effect on the Cosmic Microwave Background Radiation*, arXiv:1302.2706v1

[43] Sarkar et al, *The scale of homogeneity of the galaxy distribution in SDSS DR6*, arXiv:0906.3431v1

[44] http://galileowaswrong.com/wp-content/uploads/2013/06/Planck-Date-Release.pdf

[45] http://galileowaswrong.com/wp-content/uploads/2013/11/Interview_by_Wesley_Hunt.pdf

[46] http://galileowaswrong.com/wp-content/uploads/2014/03/BICEP21.pdf

[47] The idea that the WMAP and Planck satellite experiments were motivated by a desire to prove that the CMB is not aligned with the Earth is beyond ludicrous

[48] http://magisterialfundies.blogspot.com/2013/07/new-paper-in-astronomy-and-astrophysics.html

[49] http://magisterialfundies.blogspot.co.uk/2012/09/newest-observational-evidence-shows.html

[50] http://magisterialfundies.blogspot.co.uk/2012/01/discussion-on-geocentrism.html

[51]http://www.science20.com/news_articles/planck_helps_scientists_read_cosmic_writing_wall-107174 (in the comment box)

[52] Chapter 12, Galileo Was Wrong

[53] http://magisterialfundies.blogspot.co.uk/2013/07/new-analysis-shows-universe-aligned.html

[54] In detail, the sodium and chlorine are each on a face-centred cubic arrangement, so that each atom has six nearest neighbours of the other element in a regular octahedron.

[55] Of course, they don’t *have* a model, a fact that we shall explore below.

[56] Peebles, and Yu, *Primeval Adiabatic Perturbation in an Expanding Universe*, Astrophysical Journal 162: 815–836.

[57] Doroshkevich, Zel'Dovich, and Syunyaev, *Fluctuations of the microwave background radiation in the adiabatic and entropic theories of galaxy formation*. In Longair and Einasto *The large scale structure of the universe; Proceedings of the Symposium*. Tallinn, Estonian SSR: Dordrecht, D. Reidel Publishing Co. pp. 393–404 (1977).
[58] Planck Collaboration, *Planck Intermediate Results, XIII. Constraints on peculiar velocities,* arXiv: 1303.5090v3

[59] http://en.wikipedia.org/wiki/Tests_of_general_relativity andhttp://en.wikipedia.org/wiki/Tests_of_special_relativity
[60] It's an approximation in any case, since the universe is *not* homogeneous and isotropic up to a scale of at least 350 million light years but as far as the Standard Model is concerned, it's an acceptable approximation.
[61] Zehavi, Riess, Kirshner and Dekel, *A local Hubble bubble from SNe Ia,* arXiv:astro-ph/9802252v2
[62] Tomita K, *Distances and lensing in cosmological void models,* arXiv:astro-ph/9906027v4
[63] Alnes and Amarzguioui, *CMB anisotropies seen by an off-center observer in a spherically symmetric inhomogeneous universe,* arXiv:astr-ph/0607334v2
[64] Moffat J W, *Cosmic Microwave Background, Accelerating Universe and Inhomogeneous Cosmology,* arXiv:astro-ph/0502110v6
[65] Bellido and Haugbølle, *Looking the void in the eyes – the kSZ effect in LTB models,*arXiv:0807.1326v1
[66] Alnes, Amarzgiuoui and Grøn, *An inhomogeneous alternative to dark energy?,*arXiv:astro-ph/0512006v2
[67] Celerier M-N, *The Accelerated Expansion of the Universe Challenged by an Effect of the Inhomogeneities. A Review,* arXiv:astr-ph/0702416v2
See also: Alexander et al, *Local Void vs Dark Energy: Confrontation with WMAP and Type Ia Supernovae,* arXiv:0712.0370v3
[68] Tolman R C, *Effect of inhomogeneity on cosmological models,* PNAS 20, 169 (1934),http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1076370/pdf/pnas01743-0027.pdf

[69] Bondi H, *Spherically symmetrical models in General Relativity,* Mon Not R Astron Soc 107, 410 (1947)
http://adsabs.harvard.edu/full/1947MNRAS.107..410B
[70] There are many papers on the subject of how the inhomogeneous void blends into the homogeneous background, and for a review, see, for example: Enqvist K, *Lemaitre-Tolman-Bondi model and accelerating expansion,* arXiv:0709.2044v1
[71] Biswas, Mansouri and Notari, *Nonlinear Structure Formation and "Apparent" Acceleration: an Investigation,* arXiv:astro-ph/0606703v2
[72] Scrimgeour et al, *The WiggleZ Dark Energy Survey: the transition to large-scale cosmic homogeneity,* arXiv:1205.6812
[73] Anderson et al, *The clustering of galaxies in the SDSS-III Baryon Oscillation Spectroscopic Survey: Baryon Acoustic Oscillations in the Data Release 10 and 11 Galaxy Samples,* arXiv:1312.4877v1
[74] Riess et al, *A 3% Solution: Determination of the Hubble Constant with the Hubble Space Telescope and Wide Field Camera 3*, Astrophysical Journal, doi:10.1088/0004-637X/730/2/119
[75] For example: Aluri and Jain, *Large scale anisotropy due to pre-inflationary phase of cosmic evolution*, arXiv:1108.3643v2
[76] See for example: Rubart and Schwarz, *Cosmic radio dipole from NVSS and WENSS,*arXiv:1301.5559v3
[77] Tiwari et al, *Dipole anisotropy in sky brightness and source count distribution in radio NVSS data*, arXiv:1307.1947v3
[78] Ghosh S, *Generating Intrinsic Dipole Anisotropy in the Large Scale Structures*, arXiv:1309.6547
[79] Rubart, Bacon and Schwarz, *Impact of local structure on the cosmic radio dipole,*arXiv:1402.0376
[80] Shurtleff R, *A Large Scale Pattern from Optical Quasar Polarization Vectors*, arXiv:1311.6118v1
[81] Hawkins, Maddox and Merrifield, *No Periodicities in 2dF Redshift Survey Data,arXiv:*astro-ph/*0208117v1*
[82] Bajan et al, *On the investigations of galaxy redshift periodicity*, arXiv:astro-ph/0606294
[83] The SDSS III BOSS webpage: http://www.sdss3.org/surveys/boss.php

[84] Anderson et al, *The clustering of galaxies in the SDSS-III Baryon Oscillation Spectroscopic Survey: Baryon Acoustic Oscillations in the Data Release 10 and 11 Galaxy Samples,* arXiv:1312.4877v1
[85] Hartnett and Hirano, *Galaxy redshift abundance periodicity from Fourier analysis of number counts N(z) using SDSS and 2dF GRS galaxy surveys*, arXiv:0711.4885v3
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[87] Hirano and Komiya, *Observational tests for oscillating expansion rate of the Universe,* arXiv:1008.4456v2
[88] Bell and Comeau, *More Evidence for an Oscillation Superimposed on the Hubble Flow*, arXiv:1308.2624
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[91] http://adsabs.harvard.edu/abs/2009ASPC..413...77H
[92] http://johnhartnett.org/2014/05/26/our-galaxy-near-the-centre-of-concentric-spherical-shells-of-galaxies/