Special Report

Cosmic Background Radiation Data from Planck

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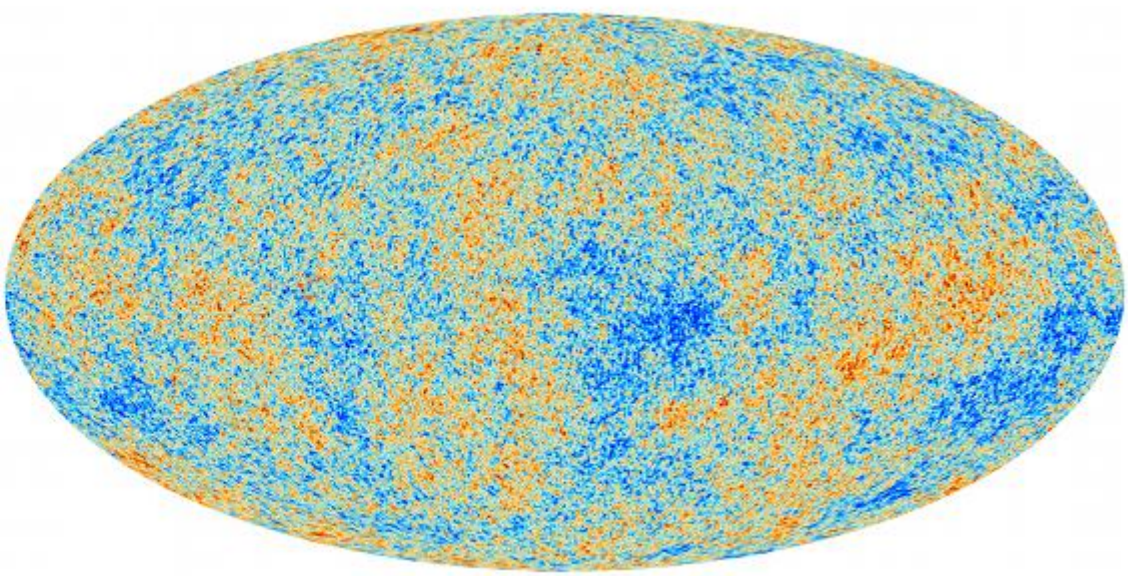
Abstract

The Planck data shows that universe is made up of 69.2±1.0% dark energy, 25.8±0.4% dark matter, and 4.82±0.05% visible matter. The percentage of dark energy increases as the universe expands while the ratio of dark to visible matter stays constant, so these figures are valid only for the present. Using the new Planck data the age of the universe is now 13.82 ± 0.05 billion years old. WMAP gave an answer of 13.77 ± 0.06 billion years. The most important plot that the Planck analysis produced is the multipole analysis of the background.

Key Words: cosmic background radiation, Planck data, dark matter, dark energy, Age of the Universe, WMAP, multipole analysis.

It is great to see the Planck cosmic background radiation data released, so what is it telling us about the universe? First off the sky map now looks like this



Planck is the third satellite sent into space to look at the CMB and you can see how the resolution has improved in this picture from Wikipedia

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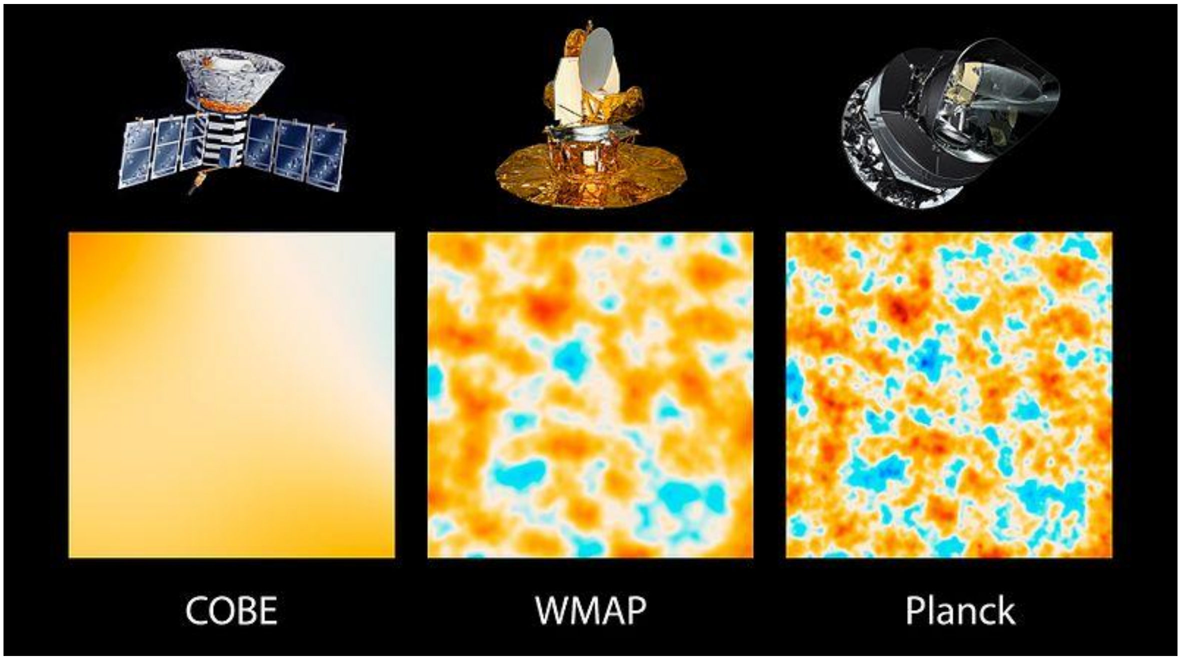
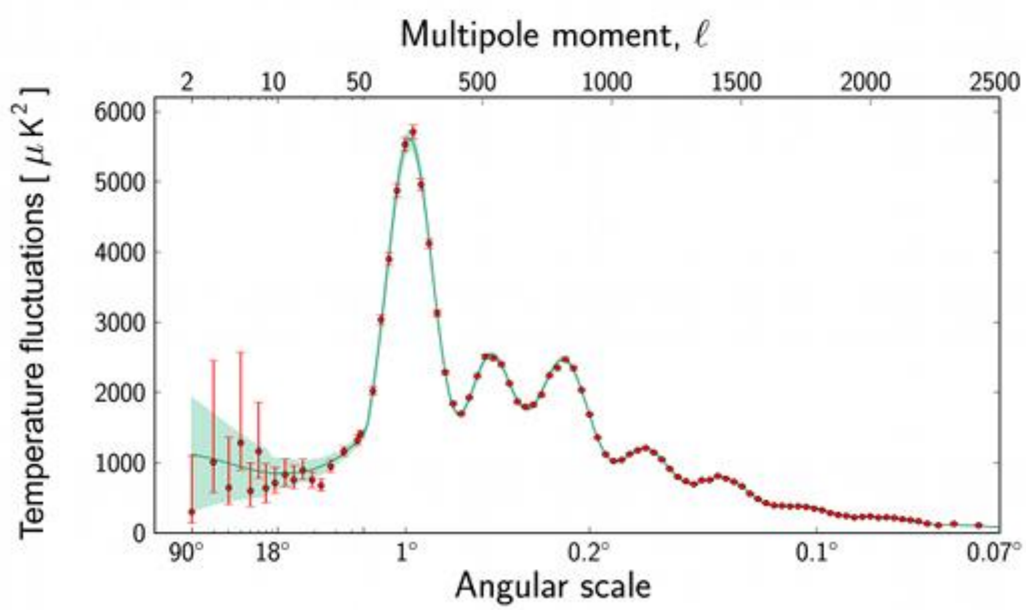


Like the LHC, Planck is a European experiment. It was launched back in 2009 on an Ariane 5 rocket along with the Herschel Space Observatory. The US through NASA also contributed though.

The Planck data has given us some new measurements of key cosmological parameters. The universe is made up of 69.2±1.0% dark energy, 25.8±0.4% dark matter, and 4.82±0.05% visible matter. The percentage of dark energy increases as the universe expands while the ratio of dark to visible matter stays constant, so these figures are valid only for the present. Contributions to the total energy of the universe also includes a small amount of electromagnetic radiation (including the CMB itself) and neutrinos. The proportion of these is small and decreases with time.

Using the new Planck data the age of the universe is now 13.82 ± 0.05 billion years old. WMAP gave an answer of 13.77 ± 0.06 billion years. In the usual spirit of bloggers combinations we bravely assume no correlation of errors to get a combined figure of 13.80 ± 0.04 billion years, so we now know the age of the universe to within about 40 million years, less than the time since the dinosaurs died out.

The most important plot that the Planck analysis produced is the multipole analysis of the background anisotropy shown in this graph



This is like a fourier analysis done on the surface of a sphere. It is believed that the spectrum comes from quantum fluctuations during the inflationary phase of the big bang. The points follow the predicted curve almost perfectly and certainly within the expected range of cosmic variance given by the grey bounds. A similar plot was produced before by WMAP but Planck has been able to extend it to higher frequencies because of its superior angular resolution.

However, there are some anomalies at the low-frequency end that the analysis team has said are in the range of 2.5 to 3 sigma significance depending on the estimator used. In a particle physics experiment this would not be much but there is no look elsewhere effect to speak of here, any these are not statistical errors that will get better with more data. This is essentially the final result. Is it something to get excited about?

To answer that it is important to understand a little of how the multipole analysis works. The first term in a multipole analysis is the monopole which is just the average value of the radiation. For the CMB this is determined by the temperature and is not shown in this plot. The next multipole is the dipole. This is determined by our motion relative to the local preferred reference frame of the CMB so it is specified by three numbers from the velocity vector. This motion is considered to be a local effect so it is also subtracted off the CMB analysis and not regarded as part of the anisotropy. The first component that does appear is the quadrupole and as can be seen from the first point on the plot. The quadrupole is determined by 5 numbers so it is shown as an average and a standard deviation. As you can see it is significantly lower than expected. This was known to be the case already after WMAP but it is good to see it confirmed. This contributes to the 3 sigma anomaly but on its own it is more like a one sigma effect, so nothing too dramatic.

In general there is a multipole for every whole number l starting with$l$=0 for the monpole, l=1 for the dipole, l=2 for the quadrupole. This number l is labelled along the x-axis of the plot. It does not stop there of course. We have an octupole for *l*=3, a hexadecapole for *l*=4, a dotriacontapole for *l*=5, a tetrahexacontapole for *l*=6, a octacosahectapole for *l*=7 etc. It goes up to *l*=2500 in this plot. Sadly I can't write the name for that point. Each multipole is described by 2*l*+1 numbers. If you are familiar with spin you will recognise this as the number of components that describe a particle of spin *l*, it's the same thing.

If you look carefully at the low-*l* end of the plot you will notice that the even-numbered points are low while the odd-numbered ones are high. This is the case up to *l*=8. In fact above that point they start to merge a range of l values into each point on the graph so this effect could extend further for all I know. Looking back at the WMAP plot of the same thing it seems that they started merging the points from about *l*=3 so we never saw this before (but some people did because they wrote papers about it). It was hidden, yet it is highly significant and for the Planck data it is responsible for the 3 sigma effect. In fact if they used an estimator that looked at the difference between odd and even points the significance might be higher.

There is another anomaly called the cold spot in the constellation of Eridanus. This is not on the axis of evil but it is terribly far off. Planck has also verified this spot first seen in the WMAP survey which is 70 µK cooler than the average CMB temperature.

What does it all mean? No idea!

References

1. http://blog.vixra.org/2013/03/22/planck-thoughts/