Essay

Planck and CMB

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Abstract

The Planck data is released. There are two kinds of anomalies associated with small angular momenta: amplitude anomalies and directional anomalies. For small even values of *l* they tend to be aligned with each other and with what is called Axis of Evil, which is almost in the orbital plane of Earth. The celestial direction angles of the Axis of Evil are (RA= 212 o, δ= 25 o). In TGD framework, a natural explanation for the Axis of Evil would be in terms of long galactic cosmic strings.

Key Words: Planck, CMB, amplitude anomaly, Axis of Evil, TGD.

Several bloggers have already commented the new Planck data (28 articles). The posting of Phil Gibbs explains in some detail what is measured and what the basic results are from the standpoint of cosmology. Second blog posting discussing the results from particle physics point of view is by Resonaances.

The basic observable is the temperature fluctuations of cosmic microwave background coded by the correlation function for the local CMB temperature and deducible from the data. The correlation function is expressible in terms of spherical harmonics which are functions of the angular separation Ω for the points of celestial sphere.

The role of standard model is played ΛCDM model involving cosmological constant and cold dark matter. Inflationary scenario is behind this model. The basic prediction is that the spectrum is Gaussian just like density fluctuations are predicted to be Gaussian. This is the simplest option that one can assume. The amplitude of the density fluctuations (and thus temperature fluctuations) is one of the non-trivial predictions. Although I am not a specialist, I dare to guess that Gaussian character dictates the predictions to a high degree.

As Phil Gibbs describes, the new data provide a much more accurate view about temperature fluctuations since higher harmonics l, which corresponds to higher scales of angular (and therefore also length scale -) resolution for a given distance/redshift, are included. The highest angular resolution is .1 degrees for Planck data.

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The data allow one to deduce fractions of dark energy, dark matter, and visible matter as 69.2+/- 1 %, 25.8+/- .4 %, and 4.82+/- .05 %. Also the age of the Universe can be estimated. The age of the Universe comes as 13.82 +/- 0.05 Giga-years.

From particle physics point of view the interesting outcome is the estimate for the number of light neutrinos which is now $N_{eff}=3.3+/- 0.5$. This does not support the idea about inert neutrinos having been in thermal equilibrium with other particles. This results is interesting also from TGD point of view (see also the earlier posting Is there an inert neutrino there?) since right handed neutrino has an exceptional role in TGD and despited the fact that it has no spinor couplings to induced electroweak gauge fields, one must consider also the possibility that via its coupling to the space-time geometry via modified Dirac equation it has managed to achieve a thermal equilibrium with other particles during early cosmology.

Amplitude anomaly

There are two kinds of anomalies associated with small angular momenta: amplitude anomalies and directional anomalies. Anomalies at the low frequency end. 2.5 to 3 sigma significance. Anomalies appear at large angular separations and thus large length scales hinting about the existence of unexpectedly large structures. By Uncertainty Principle of harmonic analysis large angular distances correspond to small "angular momenta" and lowest spherical harmonics.
The correlation function for the temperature fluctuations at two points of celestial sphere can be developed in terms of spherical harmonics as a function of $\Omega=(\theta,\varphi)$ defining the relative angular coordinates of the points.

$$\langle T(\Omega_1)T(\Omega_2)\rangle= \sum_{l,|m|=0,...,l} Q_l^m Y^l_m(\Omega) .$$

$Q_{l,m}$ are multipole strengths. Inflationary cosmological predicts Gaussian distribution in for the fluctuations as function of the angular separation. This leads to predictions for the coefficients of $Q_{l,m}$.

Dipole anomaly is the lowest anomaly but can be identified in terms of the motion of Earth with respect to CMB and by a suitable choice of the rest frame it can be eliminated. There are anomalies for also higher harmonics in Planck data up to l=10 at least. Higher harmonics are not shown in the graph of the posting of Phil Gibbs. For these values of l, odd harmonics are stronger whereas even harmonics are weaker than predicted. Why this?

Axis of Evil

To a given l one can assign direction as direction Ω for which l^{th} contribution $\sum_m Q_{lm}{}^2 Y_{l,m}$ has maximum of modulus squared of this contribution. These directions are expected to be random. For small even values of l they tend to be aligned with each other and with what is called Axis of Evil, which is almost in the orbital plane of Earth. The celestial direction angles of the Axis of Evil are (RA= 212 ^{o}, δ= 25 ^{o}).

A short digression: Right ascension RA and declination δ relate to spherical coordinates $\Omega=(\theta,\varphi)$ via the relationship ($\delta= \pi/2-\theta$, $RA=\varphi$). δ is the counterpart of Norther latitude and RA the counterpart of eastern longitude. RA =0 holds true, when the center of Sun is in the plane as the Earth's equator (note that spin axes of Earth is slightly tilted with respect to the orbital plane (see this). Axis of Evil points to a region in which the number of radio galaxies is lower than expected: the size scale of this low temperature region is 300 MPc (10^9 ly). The alignment of galactic spin directions along this direction.

Possible explanations for the Axis of Evil has been discussed. The first article that web search gave was *Goodness in the axis of evil* by Schild and Gibson. The article relies on WMAP data but gives a glimpse about the problem for the interested reader. The abstract of the article mentions the unexpected alignment of 2-4-8-16 cosmic microwave background spherical harmonic directions with the direction of a surprisingly large WMAP temperature minimum ("Axis of Evil") defining a large low temperature structure and radio galaxy void.

This cold region is *not* in the same direction as the Cold Spot for which one has RA= 3h 15min 5s and $\delta = -19^o$ 35' 02". 3h makes roughly 3× 30=90 degrees as anyone familiar with clock can conclude). The authors do not state that odd harmonics would lie in the direction of Axis of Evil: what the situation is for the new data is not clear to me.

Article mentions also the unexpected alignment and handedness of galaxy spins in the same direction up to distances of order 1.5 Gpc (pc= 3.26 Iy). The size scale of the low temperature radio galaxy void is 10^9 ly to be compared with the size scale 10^8 ly of large voids, which seem to form a honeycomb structure (for which I have considered a model based on many-sheeted space-time). I tend to agree with the authors that these long range correlations can be seen as a serious challenge the Λ QCM model which assumes cosmological constant, inflation, and cold dark matter.

In TGD framework a natural explanation for the Axis of Evil would be in terms of long galactic cosmic strings. Note that these cosmic strings have only name in common with the ordinary GUT cosmic strings. As mentioned in Not Even Wrong, Planck data show now evidence for GUT cosmic strings.

1. Cosmic strings in TGD sense are key players of TGD inspired cosmology. During primordial period they corresponds to string like objects with 2-D CP_2 and M^4 projections and later their M^4projection expands so that it becomes 4-D. The outcome is Kähler magnetic flux tubes with Kähler magnetic fields explaining the magnetic fields filling the Universe but having no natural explanation in standard cosmology. Since magnetic monopole flux having purely topological origin is in question, these fields need no current as source as ordinary magnetic fields.

2. Kähler magnetic energy is identifiable as dark energy and the magnetic tension gives rise to the "negative pressure" needed to achieve accelerated cosmic expansion. The flux tubes can decay to ordinary and dark matter in the same manner as inflaton type fields are

assumed to decay the ordinary and dark matter in inflationary scenarios. In TGD framework the flatness of 3-space corresponds to quantum criticality (no scales) rather than inflation. The Kähler magnetic energy of galaxies are assumed to be located along these string like objects like pearls along necklace. The correlations between galactic spins could be inherited from primordial period when galaxies were very near to each other and their dynamics were correlated.

3. One should understand the amplitude anomalies in terms of this model. Why even harmonics have weaker amplitudes and odd harmonics stronger amplitudes than predicted? Could one say that some power has been transferred from even to odd harmonics? Why odd parity amplitudes would be stronger? How the selection of preferred axis by the presence of cosmic string could be responsible for this effect.

Reference

1. http://matpitka.blogspot.com/2013/03/planck-and-cm.html