CBM cold spot as problem of the inflationary cosmology

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Abstract

The existence of large cold spot in CMB) is a serious problem for the inflationary cosmology. The explanation as apparent cold spot due to Sachs-Wolfe effect caused by gravitational redshift of arriving CMB photons in so called super voids along the line of sight has been subjected to severe criticism. TGD based explanation as a region with genuinely lower temperature and average density relies on the view about primordial cosmology as cosmic string dominated period during which it is not possible to speak about space-time in the sense of general relativity, and on the analog of inflationary period mediating a transition to radiation dominated cosmology in which space-time in the sense of general relativity exists. The fluctuations for the time when this transition period ended would induce genuine fluctuations in CMB temperature and density. This picture would also explain the existence super voids.

1 Introduction

The existence of large cold spot in CMB (see `http://tinyurl.com/hxgck9r`) is a serious problem for the inflationary cosmology. The distance r of the cold spot is in the range .6-1 Gly at redshift $z \sim 1$ with uncertainty coming from that for Hubble constant in the formula $z = r/Hc$.

Remark: The uncertainty in distance corresponds to the ratio 3/2 for the upper and lower ends for the range of H. TGD predicts that both cosmological constant and Hubble constant obey p-adic length scale evolution and that the smallest increment of Hubble constant is by factor $\sqrt{2}$ [L1].

The root mean square fluctuation of CMB temperature is $T = 2.7$ K is $\Delta T_{CMB} = 18$ μK: $\Delta T_{CMB}/T \sim .7 \times 10^{-5}$. The temperature fluctuation in the cold spot reduces average temperature by 70 μK corresponding to $\Delta_{spot}T/T \sim 2.6 \times 10^{-5}$. The ratio of these 2 fluctuations is $\Delta T_{CMB}/\Delta T_{spot} = 3.9$. In standard cosmological scenario density fluctuations $\Delta\rho/\rho$ is predicted to be proportional to $\Delta T/T$ and would have same order of magnitude but fluctuation in so long scale about .5-1 Gly is not plausible. That a region with lower temperature has also a lower density (not much!) is natural since density fluctuations and temperature fluctuations are proportional to each other in the standard view about the formation of structures.

This comment was inspired as a reaction to probably the most adventurous explanation for the cold spot as resulting from a collision of two Universes (see `http://tinyurl.com/ycl65svs`). At this moment multiverse exists only in the imagination of theoreticians. The cold spot is however there very concretely and cries for an explanation. It would be nice to say something interesting about it also in TGD framework.

2 Is the cold spot apparent or real?

One possible explanation for the cold spot is only apparent and due to so called integrated Sachs-Wolfe effect caused by so called super voids at the line of sight. TGD proposal is that it is real and has primordial origin.

2.1 Could the cold spot be apparent and due to supervoid and integrated Sachs-Wolfe effect?

A more conventional explanation is in terms of large voids (see `http://tinyurl.com/jyqcjhl`). These regions contain very few galaxies and the density is about 10 per cent about the density. Therefore the $\Delta/T \propto \Delta\rho/\rho$ rule cannot hold true in these regions. These regions would give rise to a reduction of the energy of the CMB photons travelling through them, which would imply an apparent reduction of CMB temperature. This effect is due to a gravitational redshift and known as integrated Sachs-Wolfe effect (ISW) (see `http://tinyurl.com/y9hd73ms`).

There is indeed evidence for a supervoid with radius of 1.8 Gly centered at distance of 3 Gly in the direction of Eridani and thus in the direction of the cold spot. According to the Wikipedia article the supervoid explaining the hot spot should have distance of 6-10 Gly and diameter about 1 Gly.

There are arguments against the explanation of hot spot in terms of large voids along the line of sight (see `http://tinyurl.com/yb5dr8w3`). According to the abstract of the article, there are voids at z = 0.14, 0.26 and 0.30 but they are interspersed with small over-densities but that the scale of these voids is insufficient to explain the Cold Spot through the ΛCDM ISW. Therefore the reduction of the temperature should have primodial origin. Second problem - at least for me - is that I do not know whether there is any convincing explanation for why the dark matter should concentrate at filaments, which in turn are found to concentrate at 2-D surfaces of large voids.

2.2 TGD inspired explanation of cold spot as something real

In TGD framework one considers flux tube network, and the formation of structures is based on different mechanism. The correlation between density and temperature fluctuations remains true in the scales in which mass density can be regarded as constant.

1. Dark mass and energy dominate over the mass density and are concentrated along cosmic strings - as knots as the simplest option proposed. It is indeed known that dark matter is distributed along filamentary structures and the outcome is a kind of honeycomb structure with most of the dark matter at the surfaces of the cells and intermediate regions formed by large voids. The average of the mass density must be taken in a scale longer than that of large voids which is in the range of .1-1 Gly.

2. Cosmic strings - flux tubes containing dark matter - would generate the visible matter both by a transformation of dark matter to ordinary matter by h_{eff} reducing phase transition and by condensation of ordinary matter around knots of cosmic strings. Long strings could form knots via temporary reconnections giving rise to spiral and elliptic galaxies (for these reconnection would form a separate closed flux tube). Stars could be formed as sub-knots of galactic knots in the same manner. One can wonder this formation mechanism is able to explain large regions with slightly lower density?

To get an idea about the possible TGD based explanation of the cold spot, one must ask what is new in TGD cosmology preceding radiation dominated phase as compared to GRT based inflationary cosmology.

1. In TGD the counterpart of pre-inflationary period is the period during, which cosmic strings dominated [K1, K4, K7, K6]. During this period there was no space-time in the conventional sense of the word - that is as a space-time surfaces having 4-D M^4 projection in $M^4 \times CP_2$. Rather, cosmic strings had 2-D string world sheets as M^4 projections. Space-time in the conventional sense emerged during the inflationary period as the thickness of M^4 projection of the originally infinitely thin) flux tubes started to increase as a response to the perturbations caused by other flux tubes and the huge magnetic fields along flux tubes started to get weaker. After the transition to radiation dominated phase it became convenient to speak about space-time in the conventional sense. Radiation was produced in the decay of cosmic string energy to radiation.

   The conservation of monopole flux of the cosmic strings (monopole flux is possible by CP_2 topology) led to the reduction of the magnetic field as $1/S$, S the area of flux tube and also energy density. There is present a volume term proportional to the cosmological constant. How the net density of the dark energy of flux tube behaved depends on how the ratio of these densities evolved but on dimensional grounds one can make the guess that the dark energy per unit length reduced as $1/L(k)^2$ where $L(k) \propto k^{-1/2}$ is the p-adic length scales assignable to $p \simeq 2^k$ and increasing during cosmic evolution as proportional to the Hubble radius.

2. The basic prediction is that the analog of the inflationary period need neither begin nor end at precisely the same time - call the latter time t_{end} - everywhere. There are fluctuations in the value of t_{end}. If the transition occurs for a given region earlier than for the environment, cosmic expansion also starts earlier, and the density of matter at later times and also temperature is lower than in the surrounding regions for the same value of M^4_+ time (light-cone proper time a, which defines the scale factor a^2 of the Robertson-Walker metric). By cosmic expansion also the scale of the large voids in these regions would be larger than in environment. This explanation would differ form the explanation in terms of supervoid in the sense that the temperature fluctuation would be real and primordial rather than apparent and caused by gravitational redshift in super-voids (ISW effect). The concentration of dark matter and energy to flux tubes would also explain super-voids. Super voids would not induce apparent temperature reduction. Rather, both super voids and temperature fluctuation would have a common primordial origin.

   Note that the fluctuations of ΔT correspond by $T/T_0 = a_0/a$ fluctuations of same size for $t_{end} = a_{end}$ (a is light-cone proper time defining the scale factor of RW metric as induced metric of space-time surface) so that the the cold spot would have $\Delta a/a_{now} \sim 2.6 \times 10^{-5}$. $g_{aa} < 1$ implying $a_{now} > t_{now}$ gives $a_{now} > 13.8$ Gy. This gives $\Delta a_{now} > (\Delta T/T)a_{now} > 3.6 \times 10^5$ y.

   The basic unanswered question is whether the the typical size scale for the fluctuation for the time t_{end} is larger than the typical size scale of the density fluctuation in standard cosmology.

3. One should also have an explanation for the concentration of flux tube structures at the surfaces of large voids. I have proposed for decades ago a model of large voids based on extremals of Kähler action. The void would have long cosmic string in the center and the return would come along the surface of the large void. This brings in mind an analog of a dipole magnetic field. Galaxies would be knots along the flux tubes of the return flux of particular dipole field. These dipoles would arrange to a kind of lattice analogous to ferromagnet or anti-ferromagnet. At the boundaries between neighboring cells there would be pairs of flux tubes arriving from different cells and carrying parallel or antiparallel fluxes.

   Classically various magnetization effects are not possible since they involve exchange interaction of spins. One can recklessly speculate that magnetized phases with parallel spins could exist at dark flux tubes as macroscopic quantum phases. Also cyclotron BE condensates would be possible. Could these make the flux tubes to behave like spins with very large $h_{eff} = n \times h = h_{gr}$ serving as a unit of spin (in renormalization group approach to statistical physics one indeed combines spins to larger block spins)? Could one speak of exchange forces between the spins at different flux tubes arising from entanglement? If so, there would be quantum coherence in cosmological scales made possible by very large values of $h_{eff} = n \times h = h_{gr}$ at flux tubes [K3, K2, K6, K5].

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