

Cyclic cosmology from TGD perspective

M. Pitkänen

Email: matpitka6@gmail.com.

<http://tgdtheory.com/>.

June 20, 2019

Contents

1	Extreme complexity of theories <i>viz</i> extreme simplicity of physics	1
2	Why the cosmology is so homogenous and isotropic?	2
3	The TGD analog of cyclic cosmology	3

Abstract

The motivation for this piece of text came from a very inspiring interview of Neil Turk by Paul Kennedy in CBS radio. The themes were the extreme complexity of theories in contrast to extreme simplicity of physics, the mysterious homogeneity and isotropy of cosmology, and the cyclic model of cosmology developed also by Turok himself. In the following I will consider these issues from TGD viewpoint. The key observation is that cosmic temperature is in excellent approximation constant. The radical proposal that this is due to quantum coherence in cosmological length scales conforms with TGD vision about dark matter hierarchy labelled by values of Planck constant and with the vision that higher levels of this hierarchy control the lower ones. TGD inspired theory of consciousness emerging as generalization of quantum measurement theory so that it applies in zero energy ontology, in turn predicts that consciousness is Zeno effect: the sequence of repeated reductions at fixed boundary of causal diamond defines self as living entity and the first reduction to opposite boundary means death and re-incarnation of self. Single lifetime of self would correspond to single cycle of cosmology at the scale of the observed Universe.

1 Extreme complexity of theories *viz* extreme simplicity of physics

The basic theme in the interview of Neil Turk by Paul Kennedy in CBS radio (see <http://tinyurl.com/hzw8k68>) was the incredible simplicity of physics in short and long scales *viz.* equally incredible complexity of the fashionable theories not even able to predict anything testable. More precisely, super string theory makes predictions: the prediction is that every imaginable option is possible. Very safe but not very interesting. The outcome is the multiverse paradigm having its roots in inflationary scenario and stating that our local Universe is just one particular randomly selected Universe in a collection of infinite number of Universes. If so then physics has reached its end.

This unavoidably brings to my mind the saying of Einstein: “Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius and a lot of courage to move in the opposite direction.”.

Turok is not so pessimistic and thinks that some deep principle has remained undiscovered. Turok’s basic objection against multiverse is that there is not a slightest thread of experimental evidence for it. In fact, I think that we can sigh for relief now: multiverse is disappearing to the sands of time, and can be seen as the last desperate attempt to establish super string theory as a respectable physical theory.

Emphasis is now in the applications of AdS/CFT correspondence to other branches of physics such as condensed matter physics and quantum computation. The attempt is to reduce the complex

strongly interaction dynamics of conformally invariant systems to gravitational interaction in higher dimensional space-time called bulk. Unfortunately this approach involves the effective field theory thinking, which led to the landscape catastrophe in superstring theory. Einstein's theory is assumed to describe low energy gravitation in AdS so that higher dimensional blackholes emerge and their interiors can be populated with all kinds of weird entities. For TGD view about the situation see [K4].

One can of course criticize Turok's view about the simplicity of the Universe. What we know that *visible* matter becomes simple both at short and long scales: we actually know very little about dark matter. Turok also mentions that in our scales - roughly the geometric mean of shortest and longest scales for the known Universe - resides biology, which is extremely complex. In TGD Universe this would be due to the fact that dark matter is the boss for living systems and the complexity of visible matter reflects that of dark matter. It could be that dark matter levels corresponding to increasing values of h_{eff}/h get increasingly complex in long scales and complexity increases. We just do not see it!

2 Why the cosmology is so homogenous and isotropic?

Turok sees as one of the deepest problems of cosmology the extreme homogeneity and isotropy of cosmic microwave background implying that two regions with no information exchange have been at the same temperature in the remote past. Classically this is extremely implausible and in GRT framework there is no obvious reason for this. Inflationary scenario is one possible mechanism explaining this: the observed Universe would have been very small region, which expanded during inflationary period and all temperature gradients were smoothed out. This paradigm has several shortcomings and there exists no generally accepted variant of this scenario.

In TGD framework one can also consider several explanations.

1. One of my original arguments for $H = M^4 \times CP_2$ was that the imbeddability of the cosmology to H forces long range correlations [K1, K3, K6]. The theory is Lorentz invariant and standard cosmologies can be imbedded inside future light-cone with its boundary representing Big Bang. Only Robertson-Walker cosmologies with sub-critical or critical mass are allowed by TGD. They are Lorentz invariant and therefore a very natural option [K3]. One would have automatically constant temperature. Could the enormous reduction of degrees of freedom due to the 4-surface property force the long range correlations? Probably not. 4-surface property is a necessary condition but very probably far from enough.
2. The primordial TGD inspired cosmology is cosmic string dominated: one has a gas of string like objects, which in the ideal case are of form $X^2 \times Y^2 \subset M^4 \times CP_2$, where X^2 is minimal surface and Y^2 complex surface of CP_2 . The strings can be arbitrarily long unlike in GUTs. The conventional space-time as a surface representing the graph of some map $M^4 \rightarrow CP_2$ does not exist during this period. The density goes like $1/a^2$, a light-cone proper time, and the mass of co-moving volume vanishes at the limit of Big Bang, which actually is reduced to "Silent Whisper" amplified later to Big Bang.

Cosmic string dominated period is followed by a quantum critical period analogous to inflationary period as cosmic strings start to topologically condense at space-time sheets becoming magnetic flux tubes with gradually thickening M^4 projections. Ordinary space-time is formed: the critical cosmology is universal and uniquely fixed apart from single parameter determining the duration of this period.

After that a phase transition to the radiation dominated phase takes place and ordinary matter emerges in the decay of magnetic energy of cosmic strings to particles - Kähler magnetic energy corresponds to the vacuum energy of inflaton field. This period would do analogous to inflationary period. Negative pressure would be due to the magnetic tension of the flux tubes.

Also the asymptotic cosmology is string dominated since the corresponding density of energy goes like $1/a^2$ as for primordial phase whereas for matter dominated cosmology it goes like $1/a^3$. This brings in mind the ekpyrotic phase of the cyclic cosmology.

3. This picture is perhaps over-simplified. Quite recently I proposed a lift of Kähler action to its 6-D twistorial counterpart [K5]. The prediction is that a volume term with positive coefficient representing cosmological constant emerges from the 6-D twistorial variant of Kähler action via dimensional reduction. It is associated with the S^2 fiber of M^4 twistor space and Planck length characterizes the radius of S^2 . Volume density and magnetic energy density together could give rise to cosmological constant behind negative pressure term. Note that cosmological term for cosmic strings reduces to similar form as that from Kähler action and depending on the value of cosmological constant only either of them or both are important. TGD suggest strongly that cosmological constant Λ has a spectrum determined by quantum criticality and is proportional to the inverse of p-adic length scale squared so that both terms could be important. If cosmological constant term is small always the original explanation for the negative pressure applies.

The vision about quantum criticality of TGD Universe would suggest that the two terms has similar sizes. For cosmic strings the cosmological term does not give pressure term since it come from the string world sheet alone. Thus for cosmic strings Kähler action would define the negative pressure and for space-time sheets both. If the contributions could have opposite signs, the acceleration of cosmic expansion would be determined by competing control variables. To my best understanding the signs of the two contributions are same (my best understanding does not however guarantee much since I am a numerical idiot and blundering with numerical factors and signs are my specialities). If the signs are opposite, one cannot avoid the question whether quantum critical Universe could be able to control its expansion by cosmic homeostasis by varying the two cosmological constants. Otherwise the control of the difference of accelerations for expansion rates of cosmic strings and space-time sheets would be possible.

4. A third argument explaining the mysterious temperature correlations relies on the hierarchy of Planck constants $h_{eff}/h = n$ labelling the levels of dark matter hierarchy with quantum scales proportional to n . Arbitrary large scales would be present and their presence would imply a hierarchy of arbitrary large space-time sheets with size characterized by n . The dynamics in given scale would be homogenous and isotropic below the scale of this space-time sheet.

One could see the correlations of cosmic temperature as a signature of quantum coherence in cosmological scales involving also entanglement in cosmic scales [K4]. Kähler magnetic flux tubes carrying monopole flux requiring no currents to generate the magnetic fields inside them would serve as correlates for the entanglement just as the wormholes serve as a correlate of entanglement in ER-EPR correlations. This would conform with the fact that the analog of inflationary phase preserves the flux tube network formed from cosmic strings. It would also explain the mysterious existence of magnetic fields in all scales.

3 The TGD analog of cyclic cosmology

Turok is a proponent of cyclic cosmology [E2, E3, E1] (see <http://tinyurl.com/hrlzdkp>) combining so called ekpyrotic cosmology and inflationary cosmology. This cosmology offers a further solution candidate for the homogeneity/isotropy mystery. Contracting phase would differ from the expanding phase in that contraction would be much slower than expansion and only during the last state there would be a symmetry between the two half-periods. In concrete realizations inflaton type field is introduced. Also scenarios in which branes near each other collide with each other cyclically and generate in this manner big crunch followed by big bang is considered. I find difficult to see this picture as a solution of the homogeneity/isotropy problem.

I however realized it is possible to imagine a TGD analog of cyclic cosmology in Zero Energy Ontology (ZEO). There is no need to assume that this picture solves the homogeneity/isotropy problem and cyclicity corresponds to kind of biological cyclicity or rather sequence of re-incarnations.

1. In ZEO the basic geometric object is causal diamond (CD), whose M^4 projection represents expanding spherical light-front, which at some moment begins to contract - this defines an intersection of future and past directed light-cones. Zero energy states are pairs of positive

and negative energy states at opposite light-like boundaries of CD such that all conserved quantum numbers are opposite. This makes it possible to satisfy conservation laws.

2. CD is identified as 4-D perceptive field of a conscious entity in the sense that the contents of conscious experiences are from CD. Does CD represent only the perceptive field of an observer getting sensory representation about much larger space-time surface continuing beyond the boundaries of CD or does the geometry of CD imply cosmology, which is Big Bang followed by a Big Crunch. Or do the two boundaries of CD define also space-time boundaries so that space-time would end there.

The conscious entity defined by CD cannot tell whether this is the case. Could a larger CD containing it perhaps answer the question? No! For larger CD the CD could represent the analog of quantum fluctuation so that space-time of CD would not extend beyond CD.

3. The geometry of CD brings in mind Big Bang - Big Crunch cosmology. Could this be forced by boundary conditions at future and past boundaries of CD meeting along the large 3-sphere forcing Big Bang at both ends of CD but in opposite directions. If CD is independent geometric entity, one could see it as Big Bang followed by Big Crunch in some sense but not in a return back to the primordial state: this would be boring and in conflict with TGD view about cosmic evolution.
4. To proceed some TGD inspired theory of consciousness is needed. In ZEO quantum measurement theory extends to a theory of consciousness. State function reductions can occur to either boundary of CD and Negentropy Maximization Principle (NMP) dictates the dynamics of consciousness [K2].

Zeno effect generalizes to a sequence of state function reductions leaving second boundary of CD and the members of zero energy states at it unchanged but changing the states at opposite boundary and also the location of CD so that the distance between the tips of CD is increasing reduction by reduction. This gives rise to the experienced flow of subjective time and its correlation with the flow of geometric time identified as the increase of this distance.

The first reduction to opposite boundary is forced to eventually occur by NMP and corresponds to state function reduction in the usual sense. It means the death of the conscious entity and its re-incarnation at opposite boundary, which begins to shift towards opposite time direction reduction by reduction. Therefore the distance between the tips of CD continues to increase. The two lives of self are lived in opposite time directions.

5. Could one test this picture? By fractality CDs appear in all scales and are relevant also for living matter and consciousness. For instance, mental images should have CDs as correlates in some scale. Can one identify some analogy for the Big Bang-Big Crunch cosmology for them? I have indeed considered what time reversal for mental images could mean and some individuals (including me) have experienced it concretely in some altered states of consciousness.

The question that I am ready to pose is easy to guess by a smart reader. Could this sequence of life cycles of self with opposite directions of time serve as TGD analog for cyclic cosmology?

1. If so, the Universe could be seen a gigantic organism dying and re-incarnating and quantum coherence even in largest scales would explain the long range correlations of temperature in terms of entanglement - in fact negentropic entanglement, which is basic new element of TGD based generalization of quantum theory.
2. Big Crunch to primordial cosmology destroying all achievements of evolution should not occur at any level of dark matter hierarchy. Rather the process leading to biological death would involve the deaths of various subsystems with increasing scale and eventually the death in the largest scale involved.
3. The system would continue its expansion and evolution from the state that it reached during the previous cycle but in opposite time direction. What would remain from previous life would be the negentropic entanglement at the evolving boundary fixed by the first reduction to the

opposite boundary, and this conscious information would correspond to static permanent part of self for the new conscious entity, whose sensory input would come from the opposite boundary of CD after the re-incarnation. Birth of organism should be analogous to Big Bang - certainly the growth of organism is something like this in metaphorical sense. Is the decay of organism analogous to Big Crunch?

4. What is remarkable that both primordial and asymptotic cosmology are dominated by string like objects, only their scales are different. Therefore the primordial cosmology would be dominated by cosmic strings thickened to cosmic strings also for the reversed cycle. Even more, the accelerated expansion could rip the space-time - this is one of the crazy looking predictions of accelerating expansion - and one would have free albeit thickened cosmic strings. In rough enough resolution they would look like ideal cosmic strings.

The re-cycling would not be trivial and boring (dare I say stupid) repeated return to the same primordial state in conflict with NMP implying endless evolution. It would involve scaling up at each rebirth. The evolution would be like a repeated zooming up of Mandelbrot fractal! Breathing is a good metaphor for this endless process of re-creation: God is breathing! Or Gods, since there is fractal hierarchy of CDs within CDs.

5. There is however a trivial problem that I did not first notice. The light-cone proper times a_{\pm} assignable to the two light-cones M_{\pm}^4 defining CD are not same. If future directed light-cone M_+^4 corresponds to $a_+^2 = t^2 - r_M^2$ with the lower tip of CD at $(t, r_M) = (0, 0)$, the light-cone proper time associated with M_-^4 corresponds $a_-^2 = (t - T)^2 - r_M^2 = a_+^2 - 2tT + T^2 = a_+^2 - 2\sqrt{a_+^2 + r_M^2}T + T^2$. The energy density would behave near the upper tip like $\rho \propto 1/a_+^2$ rather than $\rho \propto 1/a_-^2$. Does this require that a Big Crunch occurs and leads to the phase where one has gas of cosmic strings in M_-^4 ? This does not seem plausible. Rather, the gas of presumably thickened cosmic strings in M_-^4 is generated in the state function reduction to the opposite boundary. This state function reduction would be very much like the end of world and creation of a new Universe.

To sum up, single observation - the constancy of cosmic temperature - gives strong support for extremely non-trivial and apparently completely crazy conclusion that quantum coherence is present in cosmological scales and also that Universe is living organism. This should prove how incredibly important the interaction between experiment and theory is.

REFERENCES

Cosmology and Astro-Physics

- [E1] Turok N Bars I, Steinhardt P. Sailing through the big crunch-big bang transition. <http://arxiv.org/abs/1312.0739>, 2013.
- [E2] Steinhardt P. Cyclic Theory of the Universe. Available at: <http://www.physics.princeton.edu/~steinh/vasarev.pdf>.
- [E3] Hertog T Turok N, Craps B. From Big Crunch to Big Bang with AdS/CFT. <http://arxiv.org/abs/0711.1824>, 2007.

Books related to TGD

- [K1] Pitkänen M. Cosmic Strings. In *Physics in Many-Sheeted Space-Time*. Online book. Available at: <http://www.tgdtheory.fi/tgdhtml/tgdclass.html#cstrings>, 2006.
- [K2] Pitkänen M. Negentropy Maximization Principle. In *TGD Inspired Theory of Consciousness*. Online book. Available at: <http://www.tgdtheory.fi/tgdhtml/tgdconsc.html#nmpc>, 2006.

- [K3] Pitkänen M. TGD and Cosmology. In *Physics in Many-Sheeted Space-Time*. Online book. Available at: <http://www.tgdtheory.fi/tgdhtml/tgdclass.html#cosmo>, 2006.
- [K4] Pitkänen M. Holography and Quantum Error Correcting Codes: TGD View. In *Hyper-finite Factors and Dark Matter Hierarchy*. Online book. Available at: <http://www.tgdtheory.fi/tgdhtml/neuplanck.html#tensornet>, 2014.
- [K5] Pitkänen M. From Principles to Diagrams. In *Towards M-Matrix*. Online book. Available at: <http://www.tgdtheory.fi/tgdhtml/tgdquantum.html#diagrams>, 2016.
- [K6] Pitkänen M. More about TGD Inspired Cosmology. In *Physics in Many-Sheeted Space-Time*. Online book. Available at: <http://www.tgdtheory.fi/tgdhtml/tgdclass.html#cosmomore>, 2016.