Forum

On Verlinde's Entropic Gravity

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ABSTRACT

There has been a lot of talk about Verlinde's entropic gravity. The fashion and fancy hysteria familiar from the breakthough of super string models has begun. The enthusiasm is certainly partly because there are only few formulas and it is easy to tinker with them. I hope that something emerges from entropic gravity but the scenario is that the story of superstrings might repeat itself.

Key Words: entropic gravity, fashion, superstring.

Some comments about the lectures if Verlinde

I listened the lecture of Verlinde and I must say that they failed to make me enthusiastic about the idea. I try to articulate the reasons for the lack of enthusiasm.

1. I see the identification of gravitation as a force of any kind as something horribly ugly. Everyone in the field one course knows that the realization that gravitational force is not actually a force at all was the fantastic discovery of Einstein which led to general relativity whose super-symmetric version promises to be the second candidate for the UV finite quantum field theories ever discovered. For me it is horribly light-hearted to give up General Coordinate Invariance and Equivalence Principle and replace them with some thermodynamical analogies and hopelessly fuzzy notion of emergent space.
2. In any case, the priority number one would be the formulation of entropic gravity in a general coordinate invariant manner or finding whether this is possible at all. Can the thermodynamics of holographic screens indeed lead to a genuine emergence of space-time with metric? Or is this notion of emergence actually similar self deception as the emergence of continuous space-time from something discrete? How to formulate thermodynamics treating space-time coordinates as macroscopic thermodynamical parameters such that general coordinate invariance for these parameters emerges. What dictates what thermodynamical parameters playing the role of space-time coordinates are allowed? What distinguishes between the space-time coordinates and other thermodynamical parameters? Why don't we experience any generalized thermodynamical coordinate as a coordinate analogous to space-time coordinate? What distinguishes between coordinate of screen and the coordinates of space-time interior? Why the dimension of the screen should be just two? How the space-time metric defining the distance between space-time points appearing as thermodynamical parameters emerges from thermodynamics in the case that this notion has some meaning? How can one formulate the theory at practical level without relying again and again on the basic notions of special and general relativity making the arguments hopelessly circular?

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3. At least on the basis the lectures I got the impression that no dramatic progress in answering these questions has been made yet. Of course it could be that the lectures are "popular" and for this reason so fuzzy. In some arguments one takes black holes as starting point. One also brings stuff from M-theory suggesting that gravitational force between branes emerges from the interactions mediated by strings. At the same time the basic idea is however that no quantization of gravitation is needed since gravitation is indeed entropic force. The formula for the entropic force in the thermodynamics of polymers is discussed, there is good old Newton's formula for the gravitational force, and there is also Schwartschild metric and black hole horizon. How on Earth all this more or less contradictory ideas can be mutually consistent? Please, do not try to tell me that some duality brings in the harmony.

New theories have always emerged from a genuinely new ideas and new concepts. Formulas are the final outcome. To my humble opinion the tinkering with the formulas of existing theories is trying to bring life to dead bones and is dangerous because one forgets that the formulas make sense only in some context. The basic problem of the physics after the first super string revolution has been the increasing loss of conceptual economy. The loose use of dualities has led to a final loss of intellectual control and the field seems to have collapsed to a copious production of loose arguments. A thorough turnout is unavoidable sooner or later and I am afraid that both M-theory and entropic gravity end up to the recycle bin in this process.

Is 4-D holography enough?

The approach involves also holography in strong form and this is something beautiful. I see no need to complicate things by introducing fuzzy ideas about gravitation as entropic force. I have long time ago developed a beautiful theory in which space-time dimension four is completely unique.

1. The strong form of General Coordinate Invariance (GCI) plus sub-manifold gravity are all that is needed. GCI alone implies strong form of holography meaning that either light-like 3-surfaces or space-like 3-surfaces at boundaries of causal diamonds (CDs) defined as intersections of future and past directed light-cones) as basic dynamical objects. This implies effective 2-dimensionality: 2-D partonic surfaces and their 4-D tangent space data at boundaries of CDs dictate quantum physics.
2. Space-time interior defining the analog of Bohr orbit realizes quantum classical correspondence. This connection of GCI with quantum theory was something totally unexpected to say nothing about geometrization of fermion statistics in terms of gamma matrices of the world of classical worlds (the space of 3-surfaces).
3. In this framework it is also to see what goes wrong with the entropic gravity. In TGD Universe all interactions -also gravitation- can be described in terms of generalized Feynman graphs having as lines light-like 3-surfaces. The classical fields-including induced metric- at space-time surfaces provide classical correlates of these interactions required by quantum classical correspondence. The mere realization of the necessity of quantum classical correspondence might have saved us from the idea that gravitation is nothing but a macroscopic entropic force.

One might think that these discoveries alone could have some effect on colleagues but it seems that they are completely deaf to anything which does not come from the mouths of names. This opportunistic attitude is second basic disease of theoretical physics of today: it does not matter what you say, what matters who you are.

Constraint force instead of entropic force?

Entropic force does not solve the problems of general relativity based cosmology and it is only a matter of time when the claim that there is no microscopic gravitation will be shown to be wrong. There is also an article arguing that entropic gravity is in conflict with the behavior of ultracold neutrons in the gravitational field of Earth (see this) but this kind of voices are probably not heard by young career builders.

TGD however predicts a force which resolves the big problems of general relativity both at classical and quantum level. This force is the constraint force due to the condition that space-time surfaces are sub-manifolds of $M^4\times CP_2$. It is somewhat abstract force since it acts in the world of classical worlds. This force should replace entropic force as the hot topic of theoretical physics. As a matter fact, it should have become the hot topic already decades ago. Sub-manifold gravitation leads also to the geometrization of elementary particle quantum numbers and geometrization of classical gauge fields. Both the condition that standard model quantum numbers are obtained and number theoretic vision fix the imbedding space uniquely to $M^4\times CP_2$.

The huge number of unphysical degrees of freedom is the reason to the problems of both general relativity and M-theory and sub-manifold gravitation implies a huge reduction of degrees of freedom as compared to Einstein's theory. Let me represent some examples.

1. Sub-manifold constraint resolves the basic difficulty of GRT based cosmologies posed by the estimate for the natural value of cosmological constant which is by a factor of order 10^{120} too large: the solutions with infinite duration are sub-critical simply by the embeddability condition. Critical and sub-critical solutions are determined apart from parameter coding for the finite duration of this kind of cosmology.
2. The mere quantum criticality requiring flatness of 3-space in TGD inspired cosmology replaces inflation whose failure was also basically due to the exponential increase of non-physical degrees of freedom. Quantum criticality also implies accelerating expansion during critical periods: the negative pressure term is essentially due to the sub-manifold constraint. As already noticed, criticality fixes the Robertson-Walker cosmology apart from a parameter characterizing its duration.
3. The landscape catastrophe of M-theory is also due to the inflationary growth of unobserved and very probably non-existing degrees of freedom.
    (a) What one started from 26 years ago was string theory in 10-D background giving a nice description of what was believed to represent gravitonic scattering amplitudes in terms of Feynman diagrams.
    (b) The problem was that our space-time is 4-dimensional. Instead of asking whether one could replace strings with 3-surfaces- something very natural and done by me 6 years before the first superstring revolution- the idea of spontaneous compactification was introduced. Besides stringy gravitation one had now also the classical 10-D gravitation instead of having just the

4-D gravitation of Einstein's theory. Impressive! The price to be paid for these additional degrees of freedom was that one had to understand why space-time looks 4-dimensional. Still no one knows the answer and the dreams about TOE have been buried long time ago!

(c) But even this did not work! One had to introduce also branes and the result was super-exponential increase of unobserved degrees of freedom and landscape catastrophe.

(d) Did you think that this was enough? No! It seems that F-theory with 12-D target space might give some hopes about reproducing standard model quantum number spectrum?

God grief! Is it possible that no-one in the hegemony did realize what was happening?!

4. I hope that reader could get some impression about the deep frustration that I have felt during these years as I have been witnessing this odyssey from something might-be-reasonable to completely obvious non-sense. But even this is not enough! Gods really hate me! It is quite possible that I must wittness also the success of these so called phenomenological approaches to gravitation. Maybe the vision about gravitation as entropic force is some day the only game in the town! In any case, anyone need not come to me and tell that I did not warn!