TGD view about blackholes and Hawking radiation

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Abstract

Hawking has proposed a new solution to the information loss problem of blackholes. This problem is discussed in TGD framework. The intention is to demonstrate that a pseudo problem following from the failure of General Relativity below black hole horizon is in question. There are several new elements involved but concerning black holes the most relevant new element is the assignment of Euclidian space-time regions as lines of generalized Feynman diagrams implying that also blackhole interiors correspond to this kind of regions. Negentropy Maximization Principle is also an important element and predicts that number theoretically defined black hole negentropy can only increase. The real surprise was that the temperature of the variant of Hawking radiation at the flux tubes of proton Sun system is room temperature! Could TGD variant of Hawking radiation be a key player in quantum biology?

1 Introduction

The most recent revelation of Hawking was in Hawking radiation conference held in KTH Royal Institute of Technology in Stockholm. The title of the posting of Bee (http://backreaction.blogspot.fi/2015/08/hawking-proposes-new-idea-for-how.html) telling about what might have been revealed is "Hawking proposes new idea for how information might escape from black holes". Also Lubos (http://motls.blogspot.fi/2015/08/stephen-hawking-solves-information-loss.html) has - a rather aggressive - blog post about the talk. A collaboration of Hawking, Andrew

Strominger and Malcom Perry is behind the claim and the work should be published within few months.

1.1 Is information lost or not in blackhole collapse?

The basic problem is that classically the collapse to blackhole seems to destroy all information about the matter collapsing to the blackhole. The outcome is just infinitely dense mass point. There is also a theorem of classical GRT stating that blackhole has no hair: blachole is characterized only by few conserved charges.

Hawking has predicted that blackhole loses its mass by generating radiation, which looks like thermal. As blackhole radiates its mass away, all information about the material which entered to the blackhole seems to be lost. If one believes in standard quantum theory and unitary evolution preserving the information, and also forgets the standard quantum theory's prediction that state function reductions destroy information, one has a problem. Does the information really disappear? Or is the GRT description incapable to cope with the situation? Could information find a new representation?

Superstring models and AdS/CFT correspondence have inspired the proposal that a hologram results at the horizon and this hologram somehow catches the information by defining the hair of the blackhole. Since the radius of horizon is proportional to the mass of blackhole, one can however wonder what happens to this information as the radius shrinks to zero when all mass is Hawking radiated out.

What Hawking suggests is that a new kind of symmetry known as super-translations - a notion originally introduced by Bondi and Metzner - could somehow save the situation. Andrew Strominger has recently discussed the notion [B1] (`http://arxiv.org/abs/1401.7026`). The information would be "stored to super-translations". Unfortunately this statement says nothing to me nor did not say to Bee and New Scientist reporter. The idea however seems to be that the information carried by Hawking radiation emanating from the blackhole interior would be caught by the hologram defined by the blackhole horizon.

Super-translation symmetry acts at the surface of a sphere with infinite radius in asymptotically flat space-times looking like empty Minkowski space in very distant regions. The action would be translations along sphere plus Poincare transformations.

What comes in mind in TGD framework is conformal transformations of the boundary of 4-D lightcone, which act as scalings of the radius of sphere and conformal transformations of the sphere. Translations however translate the tip of the light-cone and Lorentz transformations transform the sphere to an ellipsoid so that one should restrict to rotation subgroup of Lorentz group. Besides this TGD allows huge group of symplectic transformations of $\delta CD \times CP_2$ acting as isometries of WCW and having structure of conformal algebra with generators labelled by conformal weights.

1.2 What are the problems?

My fate is to be an aggressive dissident listened by no-one, and I find it natural to continue in the role of angry old man. Be cautious, I am arrogant, I can bite, and my bite is poisonous!

1. With all due respect to Big Guys, to me the problem looks like a pseudo problem caused basically by the breakdown of classical GRT. Irrespective of whether Hawking radiation is generated, the information about matter (apart from mass, and some charges) is lost if the matter indeed collapses to single infinitely dense point. This is of course very unrealistic and the question should be: how should we proceed from GRT.

   Blackhole is simply too strong an idealization and it is no wonder that Hawking's calculation using blackhole metric as a background gives rise to blackbody radiation. One might hope that Hawking radiation is genuine physical phenomenon, and might somehow carry the information by being not genuinely thermal radiation. Here a theory of quantum gravitation might help. But we do not have it!

2. What do we know about blackholes? We know that there are objects, which can be well described by the exterior Schwartschild metric. Galactic centers are regarded as candidates for giant blackholes. Binary systems for which another member is invisible are candidates for stellar blackholes. One can however ask wether these candidates actually consist of dark matter rather than being blackholes. Unfortunately, we do not understand what dark matter is!

3. Hawking radiation is extremely weak and there is no experimental evidence pro or con. Its existence assumes the existence of blackhole, which presumably represents the failure of classical GRT. Therefore we might be seeing a lot of trouble and inspired heated debates about something, which does not exist at all! This includes both blackholes, Hawking radiation and various problems such as firewall paradox.

There are also profound theoretical problems.

1. Contrary to the intensive media hype during last three decades, we still do not have a generally accepted theory of quantum gravity. Super string models and M-theory failed to predict anything at fundamental level, and just postulate effective quantum field theory limit, which assumes the analog of GRT at the level of 10-D or 11-D target space to define the spontaneous compactification as a solution of this GRT type theory. Not much is gained.

   AdS/CFT correspondence is an attempt to do something in absence of this kind of theory but involves 10- or 11- D blackholes and does not help much. Reality looks much simpler to an innocent non-academic outsider like me. Effective field theorizing allows intellectual laziness and many problems of recent day physics will be probably seen in future as being caused by this lazy approach avoiding attempts to build explicit bridges between physics at different scales. Something very similar has occurred in hadron physics and

nuclear physics and one has kind of stable of Aigeias to clean up before one can proceed.

2. A mathematically well-defined notion of information is lacking. We can talk about thermodynamical entropy - single particle observable - and also about entanglement entropy - basically a 2-particle observable. We do not have genuine notion of information and second law predicts that the best that one can achieve is no information at all!

   Could it be that our view about information as single particle characteristic is wrong? Could information be associated with entanglement and be 2-particle characteristic? Could information reside in the relationship of object with the external world, in the communication line? Not inside blackhole, not at horizon but in the entanglement of blackhole with the external world?

3. We do not have a theory of quantum measurement. The deterministic unitary time evolution of Schrödinger equation and non-deterministic state function reduction are in blatant conflict. Copenhagen interpretation escapes the problem by saying that no objective reality/realities exist. Easy trick once again! A closely related Pandora's box is that experienced time and geometric time are very different but we pretend that this is not the case.

   The only way out is to bring observer part of quantum physics: this requires nothing less than quantum theory of consciousness. But the gurus of theoretical physics have shown no interest to consciousness. It is much easier and much more impressive to apply mechanical algorithms to produce complex formulas. If one takes consciousness seriously, one ends up with the question about the variational principle of consciousness. Yes, your guess was correct! Negentropy Maximization Principle! Conscious experience tends to maximize conscious information gain. But how information is represented?

2 TGD view about black holes and Hawking radiation

My own basic strategy is to not assume anything not necessitated by experiment or not implied by general theoretical assumptions - these of course represent the subjective element.

2.1 The basic ideas of TGD relevant for blackhole concept

The basic assumptions/predictions of TGD relevant for the recent discussion are following.

1. Space-times are 4-surfaces in $H = M^4 \times CP_2$ and ordinary space-time is replaced with many-sheeted space-time. This solves what I call energy problem of GRT by lifting gravitationally broken Poincare invariance to an exact symmetry at the level of imbedding space H.

GRT type description is an approximation obtained by lumping together the space-time sheets to single region of M^4, with various fields as sums of induced fields at space-time surface geometrized in terms of geometry of H.

Space-time surface has both Minkowskian and Euclidian regions. Euclidian regions are identified in terms of what I call generalized Feynman/twistor diagrams. The 3-D boundaries between Euclidian and Minkowskina regions have degenerate induced 4-metric and I call them light-like orbits of partonic 2-surfaces or light-like wormhole throats analogous to blackhole horizons and actually replacing them. The interiors of blackholes are replaced with the Euclidian regions and every physical system is characterized by this kind of region.

Euclidian regions are identified as slightly deformed pieces of CP_2 connecting two Minkowskian space-time regions. Partonic 2-surfaces defining their boundaries are connected to each other by magnetic flux tubes carrying monopole flux.

Wormhole contacts connect two Minkowskian space-time sheets already at elementary particle level, and appear in pairs by the conservation of the monopole flux. Flux tube can be visualized as a highly flattened square traversing along and between the space-time sheets involved. Flux tubes are accompanied by fermionic strings carrying fermion number. Fermionic strings give rise to string world sheets carrying vanishing induced em charged weak fields (otherwise em charge would not be well-defined for spinor modes). String theory in space-time surface becomes part of TGD. Fermions at the ends of strings can get entangled and entanglement can carry information.

2. Strong form of General Coordinate Invariance (GCI) states that light-like orbits of partonic 2-surfaces on one hand and space-like 3-surfaces at the ends of causal diamonds on the other hand provide equivalent descriptions of physics. The outcome is that partonic 2-surfaces and string world sheets at the ends of CD can be regarded as basic dynamical objects.

   Strong form of holography states the correspondence between quantum description based on these 2-surfaces and 4-D classical space-time description, and generalizes AdS/CFT correspondence. Conformal invariance is extended to the huge super-symplectic symmetry algebra acting as isometries of WCW and having conformal structure. This explains why 10-D space-time can be replaced with ordinary space-time and 4-D Minkowski space can be replaced with partonic 2-surfaces and string world sheets. This holography looks very much like the one we are accustomed with!

3. Quantum criticality of TGD Universe fixing the value(s) of the only coupling strength of TGD (Kähler coupling strength) as analog of critical temperature. Quantum criticality is realized in terms of infinite hierarchy of sub-algebras of super-symplectic algebra actings as isometries of WCW, the "world of classical worlds" consisting of 3-surfaces or by holography preferred extremals associated with them.

Given sub-algebra is isomorphic to the entire algebra and its conformal weights are $n \geq 1$-multiples of those for the entire algebra. This algebra acts as conformal gauge transformations whereas the generators with conformal weights $m < n$ act as dynamical symmetries defining an infinite hierarchy of simply laced Lie groups with rank $n-1$ acting as dynamical symmetry groups defined by Mac-Kay correspondence so that the number of degrees of freedom becomes finite. This relates very closely to the inclusions of hyper-finite factors - WCW spinors provide a canonical representation for them.

This hierarchy corresponds to a hierarchy of effective Planck constants $h_{eff} = n \times h$ defining an infinite number of phases identified as dark matter. For these phases Compton length and time are scale up by n so that they give rise to macroscopic quantum phases. Super-conductivity is one example of this kind of phase - charge carriers could be dark variants of ordinary electrons. Dark matter appears at quantum criticality and this serves as an experimental manner to produce dark matter. In living matter dark matter identified in this manner would play a central role. Magnetic bodies carrying dark matter at their flux tubes would control ordinary matter and carry information.

4. I started the work with the hierarchy of Planck constants from the proposal of Nottale stating that it makes sense to talk about gravitational Planck constant $\hbar_{gr} = GMm/v_0$, $v_0/c \leq 1$ (the interpretation of symbols should be obvious). Nottale found that the orbits of inner and outer planets could be modelled reasonably well by applying Bohr quantization to planetary orbits with tge value of velocity parameter differing by a factor 1/5. In TGD framework h_{gr} would be associated with magnetic flux tubes mediating gravitational interaction between Sun with mass M and planet or any object, say elementary particle, with mass m. The matter at the flux tubes would be dark as also gravitons involved. The Compton length of particle would be given by GM/v_0 and would not depend on the mass of particle at all.

   The identification $h_{gr} = h_{eff}$ is an additional hypothesis motivated by quantum biology, in particular the identification of biophotons as decay products of dark photons satisfying this condition. As a matter fact, one can talk also about h_{em} assignable to electromagnetic interactions: its values are much lower. The hypothesis is that when the perturbative expansion for two particle system does not converge anymore, a phase transition increasing the value of the Planck constant occurs and guarantees that coupling strength proportional to $1/h_{eff}$ increases. This is one possible interpretation for quantum criticality. TGD provides a detailed geometric interpretation for the space-time correlates of quantum criticality.

   Macroscopic gravitational bound states not possible in TGD without the assumption that effective string tension associated with fermionic strings and dictated by strong form of holography is proportional to $1/h_{eff}^2$. The bound states would have size scale of order Planck length since for longer systems string energy would be huge. $h_{eff} = h_{gr}$ makes astroscopic quantum coherence unavoidable. Ordinary matter is condensed around dark matter. The counterparts of black holes would be systems consisting of only dark matter.

5. Zero energy ontology (ZEO) is central element of TGD. There are many motivations for it. For instance, Poincare invariance in standard sense cannot make sense since in standard cosmology energy is not conserved. The interpretation is that various conserved quantum numbers are length scale dependent notions.

   Physical states are zero energy states with positive and negative energy parts assigned to ends of space-time surfaces at the light-like boundaries of causal diamonds (CDs). CD is defined as Cartesian products of CP_2 with the intersection of future and past directed lightcones of M^4. CDs form a fractal length scale hierarchy. CD defines the region about which single conscious entity can have conscious information, kind of 4-D perceptive field. There is a hierarchy of WCWs associated with CDs. Consciously experienced physics is always in the scale of given CD.

   Zero energy states identified as formally purely classical WCW spinor fields replace positive energy states and are analogous to pairs of initial and final, states and the crossing symmetry of quantum field theories gives the mathematical motivation for their introduction.

6. Quantum measurement theory can be seen as a theory of consciousness in ZEO. Conscious observer or self as a conscious entity becomes part of physics. ZEO gives up the assumption about unique universe of classical physics and restricts it to the perceptive field defined by CD.

   In each quantum jump a re-creation of Universe occurs. Subjective experience time corresponds to state function reductions at fixed, passive bounary of CD leaving it invariant as well as state at it. The state at the opposite, active boundary changes and also its position changes so that CD increases state function by state function reduction doing nothing to the passive boundary. This gives rise to the experienced flow of geometric time since the distance between the tips of CD increases and the size of space-time surfaces in the quantum superposition increases. This sequence of state function reductions is counterpart for the unitary time evolution in ordinary quantum theory.

   Self "dies" as the first state function reduction to the opposite boundary of CD meaning re-incarnation of self at it and a reversal of the arrow of geometric time occurs: CD size increases now in opposite time direction as the opposite boundary of CD recedes to the geometric past reduction by reduction.

   Negentropy Maximization Principle (NMP) defines the variational principle of state function reduction. Density matrix of the subsystem is the universal observable and the state function reduction leads to its eigenspaces. Eigenspaces, not only eigenstates as usually.

   Number theoretic entropy makes sense for the algebraic extensions of rationals and can be negative unlike ordinary entanglement entropy. NMP can therefore lead to a generation of NE if the entanglement correspond to a unitary entanglement matrix so that the density matrix of the final state is higher-D unit matrix. Another possibility is that entanglement matrix is algebraic but that its diagonalization in the algebraic extension of rationals used is not possible. This is expected to reduce the rate for the reduction since a phase transition increasing the size of extension is needed.

The weak form of NMP does not demand that the negentropy gain is maximum: this allow the conscious entity responsible for reduction to decide whether to increase maximally NE resources of the Universe or not. It can also allow larger NE increase than otherwise. This freedom brings the quantum correlates of ethics, moral, and good and evil. p-Adic length scale hypothesis and the existence of preferred p-adic primes follow from weak form of NMP and one ends up naturally to adelic physics.

2.2 The analogs of blackholes in TGD

Could blackholes have any analog in TGD? What about Hawking radiation? The following speculations are inspired by the above general vision.

1. Ordinary blackhole solutions are not appropriate in TGD. Interior space-time sheet of *any* physical object is replaced with an Euclidian space-time region. Also that of blackhole by perturbation argument based on the observation that if one requires that the radial component of blackhole metric is finite, the horizon becomes light-like 3-surface analogous to the light-like orbit of partonic 2-surface and the metric in the interior becomes Euclidian.

2. The analog of blackhole can be seen as a limiting case for ordinary astrophysical object, which already has blackhole like properties due to the presence of $h_{eff} = n \times h$ dark matter particles, which cannot appear in the same vertices with visible manner. Ideal analog of blackhole consist of dark matter only, and is assumed to satisfy the $h_{gr} = h_{eff}$ already discussed. It corresponds to region with a radius equal to Compton length for arbitrary particle $R = GM/v_0 = r_S/2v_0$, where r_S is Schwartschild radius. Macroscopic quantum phase is in question since the Compton radius of particle does not depend on its mass. Blackhole limit would correspond to $v_0/c \to 1$ and dark matter dominance. This would give $R = r_S/2$. Naive expectation would be $R = r_S$ (maybe factor of two is missing somewhere: blame me!).

3. NMP implies that information cannot be lost in the formation of blackhole like state but tends to increase. Matter becomes totally dark and the NE with the partonic surfaces of external world is preserved or increases. The ingoing matter does not fall to a mass point but resides at the partonic 2-surface which can have arbitrarily large surface. It can have also wormholes connecting different regions of a spherical surface and in this manner increase its genus. NMP, negentropy , negentropic entanglement between $h_{eff} = n \times h$ dark matter systems would become the basic notions instead of second law and entropy.

4. There is now a popular article (`https://www.sciencenews.org/article/hawking-proposes-solution-black-hole-problem` explaining the intuitive picture behind Hawking's proposal. The blackhole horizon would involve tangential flow of light and particles of the infalling matter would induce supertranslations on the pattern of this light thus coding information about their properties to this light. After that this light would be radiated away as analog of Hawking radiation and carry out this information.

The objection would be that in GRT horizon is no way special - it is just a coordinate singularity. Curvature tensor does not diverge either and Einstein tensor and Ricci scalar vanish. This argument has been used in the firewall debates to claim that nothing special should occur as horizon is traversed. So: why light would rotate around it? No reason for this!

The answer in TGD would be obvious: horizon is replaced for TGD analog of blackhole with a light-like 3-surface at which the induced metric becomes Euclidian. Horizon becomes analogous to light front carrying not only photons but all kinds of elementary particles. Particles do not fall inside this surface but remain at it!

The objection now is that photons of light front should propagate in direction normal to it, not parallel. The point is however that this light-like 3-surface is the surface at which induced 4-metric becomes degenerate: hence massless particles live on it.

5. The replacement of second law with NMP leads to ask whether a generalization of blackhole thermodynamics (`https://en.wikipedia.org/wiki/Black_hole_thermodynamics`) does make sense. Since blackhole thermodynamics characterizes Hawking radiation, the generalization could make sense at least if there exist analog for the Hawking radiation (`https://en.wikipedia.org/wiki/Hawking_radiation`). Note that also geometric variant of second law makes sense.

   Could the analog of Hawking radiation be generated in the first state function reduction to the opposite boundary, and be perhaps be assigned with the sudden increase of radius of the partonic 2-surface defining the horizon? Could this burst of energy release the energy compensating the generation of gravitational binding energy? This burst would however have totally different interpretation: even gamma ray bursts from quasars could be considered as candidates for it and temperature would be totally different from the extremely low general relativistic Hawking temperature of order

$$T_{GR} = \frac{\hbar}{8\pi GM} \ ,$$

   which corresponds to an energy assignable to wavelength equal to 4π times Schwartschild radius. For Sun with Schwartschild radius $r_S = 2GM = 3$ km one has $T_{GR} = 3.2 \times 10^{-11}$ eV.

One can of course have fun with formulas to see whether the generalizaton assuming the replacement $h \to h_{gr}$ could make sense physically. Also the replacement $r_S \to R$, where R is the real radius of the star will be made.

1. Blackhole temperature can be formally identified as surface gravity

$$T = \frac{\hbar_{gr}}{\hbar}\frac{\hbar GM}{2\pi R^2} = \frac{m}{8\pi v_0}\frac{r_S^2}{R^2} \ .$$

For Sun with radius $R = 6.96 \times 10^5$ km one has $T/m = 3.2 \times 10^{-11}$ giving about 3×10^{-2} eV for proton. This is by 9 orders higher than ordinary Hawking temperature. Amazingly, this temperature equals to room temperature! Is this a mere accident? If one takes seriously TGD inspired quantum biology in which quantum gravity plays a key role [K5], this does not seem to be the case. Note that for electron the temperature would correspond to energy $3/2 \times 10^{-5}$ eV which corresponds to 4.5 GHz frequency for ordinary Planck constant.

It must be however made clear that the value of v_0 for dark matter coupling to Sun via flux tubes could differ from that deduced assuming that *entire gravitational mass* of Sun couples to dark matter particles at inner planets [K3]. It could be also that only the dark portion of solar mass couples to dark matter particles. For $M \to M_D = kM$ and $v_0 \to \sqrt{k}v_0$ the orbital radii remain unchanged but the velocity of dark matter object at the orbit scales by $\sqrt{k}$. Planets and possible dark matter objects at planetary orbits would move with different velocities. This kind of scaling is suggested by the fact that the value of h_{gr} seems to be too large as compared to its estimate from the identification of bio-photons as decay results of dark photons with $h_{eff} = h_{gr}$ (some arguments suggest the value $k \simeq 2 \times 10^{-4}$) [K4].

Note that for the radius $R = r_S/2\sqrt{v_0\pi}$ the thermal energy exceeds the rest mass of the particle. For neutron stars this limit might be achieved.

2. Blackhole entropy

$$S_{GR} = \frac{A}{4\hbar G} = 4\pi \frac{GM^2}{\hbar} = 4\pi \frac{M^2}{M_{Pl}^2}$$

would be replaced with the negentropy for dark matter making sense also for systems containing both dark and ordinary matter. The negentropy $N(m)$ associated with a flux tube of given type would be a fraction h/h_{gr} from the total area of the horizon using Planck area as a unit:

$$N(m) = \frac{h}{h_{gr}} \times \frac{A}{4\hbar G} = \frac{h}{h_{gr}} \times \frac{R^2}{r_S^2} S_{GR} = v_0 \frac{M}{m} \frac{R^2}{r_S^2} \ .$$

The dependence on m makes sense since a given flux tube type characterized by mass m determining the corresponding value of h_{gr} has its own negentropy and the total negentropy is the sum over the particle species. The negentropy of Sun is numerically much smaller that corresponding blackhole entropy.

3. Horizon area is proportional to $(GM/v_0)^2 \propto h_{eff}^2$ and should increase in discrete jumps by scalings of integer and be proportional to n^2.

How does the analog of blackhole evolve in time? The evolution consists of sequences of repeated state function reductions at the passive boundary of CD followed by the first reduction to the opposite boundary of CD followed by a similar sequence. These sequences are analogs of unitary time evolutions. This defines the analog of blackhole state as a repeatedly re-incarnating conscious entity and having

CD, whose size increases gradually. During given sequence of state function reductions the passive boundary has constant size. About active boundary one cannot say this since it corresponds to a superposition of quantum states.

The reduction sequences consist of life cycles at fixed boundary and the size of blackhole like state as of any state is expected to increase in discrete steps if it participates to cosmic expansion in average sense. This requires that the mass of blackhole like object gradually increases. The interpretation is that ordinary matter gradually transforms to dark matter and increases dark mass $M = R/G$.

Cosmic expansion is not observed for the sizes of individual astrophysical objects, which only co-move. The solution of the paradox is that they suddenly increase their size in state function reductions. This hypothesis allows to realize Expanding Earth hypothesis in TGD framework [K2]. Number theoretically preferred scalings of blackhole radius come as powers of 2 and this would be the scaling associated with Expanding Earth hypothesis.

2.3 More about BMS supertranslations

Bee (see `http://tinyurl.com/z4p9h7l`) had a blog posting about the new proposal of Hawking, Perry and Strominger (HPS, see `http://arxiv.org/abs/1601.00921`) [**?**] to solve the blackhole information loss problem. In the article Maxwellian electrodynamics is taken as a simpler toy example.

1. One can assign to gauge transformations conserved charges. Gauge invariance tells that these charges vanish for all gauge transformations, which approach trivial transformation at infinity. Now however it is assumed that this need not happen. The assumption that action is invariant under these gauge transformations requires that the radial derivative of the function Φ defining gauge transformation approaches zero at infinity but gauge transformation can be non-trivial in the angle coordinates of sphere S^2 at infinity. The allowance of these gauge transformations implies infinite number of conserved charges and QED is modified. The conserved gauge charges are generalizations of ordinary electric charged defined as electric fluxes (defining zero energy photons too) and reduce to electric gauge fluxes with electric field multiplied by Φ.

2. For Maxwell's theory the ordinary electric charged defined as gauge flux must vanish. The coupling to say spinor fields changes the situation and due to the coupling the charge as flux is expressible in terms of fermionic oscillator operators and those of U(1) gauge field . For non-constant gauge transformations the charges are at least formally non-trivial even in absence of the coupling to fermions and linear in quantized U(1) gauge field.

3. Since these charges are constants of motion and linear in bosonic oscillator operators, they create or annihilate gauge bosons states with vanishing energy: hence the term soft hair. Holographists would certainly be happy since the charges could be interpreted as representing pure information. If one considers only the part of charge involving annhilation operators one can consider the possibility that in quantum theory physical states are eigenstates of these "half charges" and thus coherent states which are the quantum analogs of classical

states. Infinite vacuum degeneracy would be obtained since one would have infinite number of coherent states labelled by the values of the annihilation operator parts of the charges. A situation analogous to conformal invariance in string models is obtained if all these operators either annihilate the vacuum state or create zero energy state.

4. If these U(1) gauge charges create new ground states they could carry information about matter falling into blackhole. Particle physicist might protest this assumption but one cannot exclude it. It would mean generalization of gauge invariance to allow gauge symmetries of the proposed kind. What distinguishes U(1) gauge symmetry from non-Abelian one is that fluxes are well-defined in this case.

5. In the gravitational case the conformal transformations of the sphere at infinity replace U(1) gauge transformations. Usually conformal invariance would requite that almost all conformal charges vanish but now one would not assume this. Now physical states would be eigentates of annihilation operator parts of Virasoro generators L_n and analogous to coherent states and code for information about the ground state. In 4-D context interpretation as strong form of holography would make sense.The critical question is why should one give up conformal invariance as gauge symmetry in the case of blackholes.

It is is interesting to look TGD analogy for BMS supertranslation symmetries. Not for solving problems related to blackholes - TGD is not plagued by these problems - but because the analogs of these symmetries are very important in TGD framework.

1. In TGD framework conformal transformations of boundary of causal diamond (CD) correspond to the analogs of BMS transformations. Actually conformal transformations of not only sphere (with constant value of radial coordinate labeling points of light rays emerging from the tip of the light-cone boundary) but also in radial degrees of freedom so that conformal symmetries generalize. This happens only in case of 4-D Minkowski space and also for the light-like 3-surfaces defining the orbits of partonic 2-surfaces. One actually obtains a huge generalization of conformal symmetries. As a matter of fact, Bee wondered whether the information related to radial degrees of freedom is lost: one might argue that holography eliminates them.

2. Amusingly, one obtains also the analogs of U(1) gauge transformations in TGD! In TGD framework symplectic transformations of light-cone boundary times CP_2 act like U(1) gauge transformations but are not gauge symmetries for Kähler action except for vacuum extremals! This is assumed in the argument of the article to give blackhole its soft hair but without any reasonable justification. One can assign with these symmetries infinite number of non-trivial conserved charges: super-symplectic algebra plays a fundamental role in the construction of the geometry of "World of Classical Worlds" (WCW).

   At imbedding space level the counterpart for the sphere at infinity in TGD with the sphere at which the lightcone-boundaries defining the boundary of

causal diamond (CD) intersect. At the level of space-time surfaces the light-like orbits of partonic 2-surfaces at which the signature of the induced metric changes are the natural counterparts of the 3-surface at infinity.

In TGD framework Noether charges vanish for some subalgebra of the entire algebra isomorphic to it and one obtains a hierarchy of quantum states (infinite number of hierarchies actually) labelled by an integer identifiable in terms of Planck constant $h_{eff}/h = n$. If colleagues managed to realize that BMS has a huge generalization in the situation when space-times are surface in $H = M^4 \times CP_2$, floodgates would be open.

One obtains a hierarchy of breakings of superconformal invariance, which for some reason has remained un-discovered by string theorists. The natural next discovery would be that one indeed obtains this kind of hierarchy by demanding that conformal gauge charges still vanish for a sub-algebra isomorphic with the original one. Interesting to see who will make the discovery. String theorists have failed to realize also the completely unique aspects of generalized conformal invariance at 3-D light-cone boundary raising dimension $D = 4$ to a completely unique role. To say nothing about the fact that M^4 and CP_2 are twistorially completely unique. I would continue the list but it seems that the emergence super string elite has made independent thinking impossible, or at least the communications of the outcomes of independent thinking.

Does one obtain the analogs of generalized gauge fluxes for Kähler action in TGD framework?

1. The first thing to notice is that Kähler gauge potentials are not the primary dynamical variables. This role is taken by the imbedding space coordinates. The symplectic transformations of CP_2 act like gauge transformations mathematically but affect the induced metric so that Kähler action does not remain invariant. The breaking is small due to the weakness of the classical gravitation. Indeed, if symplectic transformations are to define isometries of WCW, they cannot leave Kähler action invariant since the Kähler metric would be trivial! One can deduce symplectic charges as Noether charges and they might serve as analogs fo the somewhat questionable generalized gauge charges in HPS proposal.

2. If the counterparts of the gauge fluxes make sense they must be associated with partonic 2-surfaces serving as basic building bricks of elementary particles. Field equations do not follow from independent variations of Kähler gauge potential but from that of imbedding space coordinates. Hence identically conserved Kähler current does not vanish for all extremals. Indeed, so called massless extremals (MEs) [K1] can carry a non-vanishing light-like Kähler current, whose direction in the general case varies. MEs are analogous to laser beams and if the current is Kähler charged it means that one has massless charged particle.

3. Since Kähler action is invariant also under ordinary gauge transformations one can formally derive the analog of conserved gauge charge for non-constant

gauge transformation Φ. The question is whether this current has any physical meaning.

One obtains current as contraction of Kähler form and gradient of Φ:

$$j_\Phi^\alpha = J^{\alpha\beta}\partial_\beta\Phi \ , \tag{2.1}$$

which is conserved only if Kähler current vanishes so that Maxwell's equations are true or if the contraction of Kähler current with gradient of Φ vanishes:

$$j_\Phi^\alpha\partial_\alpha\Phi = 0 \ . \tag{2.2}$$

The construction of preferred extremals leads to the proposal that the flow lines of Kähler current are integrable in the sense that one can assign a global coordinate Ψ with them. This means that Kähler current is proportional to gradient of scalar function Ψ:

$$j_\Phi^\alpha = g^{\alpha\beta}\partial_\beta\Psi \ . \tag{2.3}$$

This implies that the gradients of Φ and Ψ are orthogonal. If Kähler current is light-like as it is for the known extremals, Φ is superposition of light-like gradient of Ψ and of two gradients in a sub-space of tangent space analogous to space of two physical polarizations. Essentially the local variant of the polarization-wave vector geometry of the modes of radiative solutions of Maxwell's equations is obtained. What is however important that superposition is possible only for modes with the same local direction of wave vector ($\nabla\Psi$) and local polarization.

Kähler current would be scalar function k times gradient of Ψ :

$$j_\Phi^\alpha = kg^{\alpha\beta}\partial_\beta\Psi \ . \tag{2.4}$$

The proposal for preferred extremals generalizing at least MEs leads to the proposal that the extremals define two light-like coordinates and two transversal coordinates.

4. The conserved current decomposes to a sum of interior and boundary terms. Consider first the boundary term. The boundary contributions to the generalized gauge charge is given by the generalized fluxes

$$Q_{\delta,\Phi} = \oint J^{tn}\Phi g^{1/2} \tag{2.5}$$

over partonic 2-surfaces at which the signature of the induced metric changes from Euclidian to Minkowskian. These contributions come from both sides of partonic 2-surface corresponding to Euclidian and Minkowskian metric and they differ by a imaginary unit coming from $g^{1/2}$ at the Minkoskian side. $Q_{\delta,\Phi}$ could vanish since $g^{1/2}$ approaches zero because the signature of the induced metric changes at the orbit of the partonic 2-surfaces. What happens depends on how singular the electric component of gauge potential is allow to be. Weak form of electric magnetic duality proposed as boundary condition implies that the electric flux reduces to magnetic flux in which case the result would be magnetic flux weighted by Φ.

5. Besides this there is interior contribution, which is Kähler current multiplied by -Φ:

$$Q_{int,\Phi} = \int j^t \Phi g^{1/2} \ . \tag{2.6}$$

This contribution is present for MEs.

6. Could one interpret these charges as genuine Noether charges? Maybe! The charges seem to have physical meaning and they depend on extremals. The functions Φ could even have some natural physical interpretation. The modes of the induced spinor fields are localized at string world sheets by strong form of holography and by the condition that electric charge is well defined notion for them. The modes correspond to complex scalar functions analogous to powers z^n associated with the modes of conformal fields. Maybe the scalar functions could be assigned to the second quantized fermions. Note that one cannot interpret these contributions in terms of oscillator operators since the second quantization of the induced gauge fields does not make sense. This would conform with strong form of holography which in TGD framework sense that the descriptions in terms of fundamental fermions and in terms of classical dynamics of Kähler action are dual. This duality suggest that the quantal variants of generalized Kähler charges are expressible in terms of fermionic oscillator operators generating also bosonic states as analogs of bound states. The generalized charge eigenstates might be also seen as analogs of coherent states.

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