SUSY in TGD Universe

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Abstract

Contrary to the original expectations, TGD seems to allow a generalization of the space-time SUSY to its 8-D variant with masslessness in 4-D sense replaced with masslessness in 8-D sense. The algebra in question is the Clifford algebra of fermionic oscillator operators associated with given partonic 2-surface. In terms of these algebras one can in turn construct generators super-symplectic algebra as stringy Noether charges and also other super-conformal algebras and even their Yangians used to create quantum states. This also forces to generalize twistor approach to give 8-D counterparts of ordinary 4-D twistors.

The 8-D analog of super Poincare algebra emerges at the fundamental level through the anti-commutation relations of the fermionic oscillator operators. For this algebra $\mathcal{N} = \infty$ holds true. Most of the states in the representations of this algebra are massive in $4-D$ sense. The restriction to the massless sector gives the analog of ordinary SUSY with a finite value of $\mathcal{N}$ - essentially as the number of massless states of fundamental fermions to be distinguished from elementary fermions. The addition of a fermion in particular mode defines particular super-symmetry. This super-symmetry is broken due to the dynamics of the Kähler-Dirac operator, which also mixes M^4 chiralities inducing massivation. Since right-handed neutrino has no electro-weak couplings the breaking of the corresponding super-symmetry should be weakest.

The question is whether this SUSY has a restriction to a SUSY algebra at space-time level and whether the QFT limit of TGD could be formulated as a generalization of SUSY QFT. There are several problems involved.

1. In TGD framework super-symmetry means addition of a fermion to the state and since the number of spinor modes is larger states with large spin and fermion numbers are obtained. This picture does not fit to the standard view about super-symmetry. In particular, the identification of theta parameters as Majorana spinors and super-charges as Hermitian operators is not possible.

   The belief that Majorana spinors are somehow an intrinsic aspect of super-symmetry is however only a belief. Weyl spinors meaning complex theta parameters are also possible. Theta parameters can also carry fermion number meaning only the super-charges carry fermion number and are non-hermitian. The general classification of super-symmetric theories indeed demonstrates that for $D = 8$ Weyl spinors and complex and non-hermitian super-charges are possible. The original motivation for Majorana spinors might come from MSSM assuming that right handed neutrino does not exist. This belief might have also led to string theories in D=10 and D=11 as the only possible candidates for TOE after it turned out that chiral anomalies cancel.

   In superstring theory the hermiticity of super generator G_0 giving as its square scaling generator L_0 is strong argument in favor if Majorana spinors since G_0 appears as a propagator. In TGD framework the counterparts of G_0 in quark and lepton sector carry fermion number so that identification as a propagator does not make sense. The recent formulation of scattering amplitudes in terms of Yangian algebra allows to circumvent the problem. Fundamental propagators are fermion propagators for fermions massless in 8-D sense.

2. The spinor components of imbedding space spinors identifiable with physical helicities and with fixed fermion number correspond to the generators of the SUSY algebra at QFT limit. This SUSY is broken due to electroweak and color interactions. Right-handed neutrinos do not have these interactions but there is a mixing with left-handed neutrinos due to the mixing of M^4 and CP_2 gamma matrices in the Kähler-Dirac gamma matrices appearing in the K-D action. Therefore also the $\mathcal{N} = 2$ sub-SUSY generated by right-handed neutrinos is broken.

In this chapter the details of the above general picture are discussed. Also the existing experimental constraints on SUSY are discussed.

1 Introduction

TGD based vision about space-time supersymmetry has developed rather slowly.

1. From the beginning it was clear that super-conformal symmetry is realized in TGD but differs in many respects from the more standard realizations such as $\mathcal{N} = \infty$ SUSY realized in MSSM [B1] involving Majorana spinors in an essential manner.

The covariantly constant right-handed neutrino generates the super-symmetry at the level of CP_2 geometry and the idea was that the construction of super-partners would be more or less equivalent with the addition of covariantly constant right-handed neutrino and antineutrinos. It was however not clear whether space-time supersymmetry is realized at all since one could argue that that these states are just gauge degrees of freedom.Much later it became clear that covariantly constant right handed neutrino indeed represents gauge degree of freedom at space-time level.

2. A more general general SUSY algebra is generated by the modes of the Kähler-Dirac operator at partonic 2-surface. This algebra can be associated with ends of the boundaries of string world sheets and each string defines its own sub-algebra of oscillator operators.

   At first it would seem that the value of $\mathcal{N}$ can be very large-even infinite. If the conformal algebra associate with the spinor modes localized at string world sheets annihilates physical states the algebra becomes however finite-dimensional, and its dimension is the number of spinor components of the imbedding space spinor possessing physical imbedding space helicity. Furthermore, SUSY limit corresponds to the dynamics of the massless states in 4-D rather than 8-D sense so that $\mathcal{N}$ is necessarily finite. For full theory with particles which are massless in 8-D sense $\mathcal{N} = \infty$ indeed holds true.

   It is quite possible that conformal symmetry also for this superconformal algebra is broken so that only the generators for which the conformal weight is proportional to integer $n = 1, 2...$ annihilate the physical states. This increases the value of $\mathcal{N}$ by factor n and a possible interpretation is in terms of improved measurement resolution.

   For this algebra the SUSY in 4-D sense is expected to be broken. First, the notion of masslessness is generalized: fermions associated with the boundaries of string world sheets have light-like 8-momentum and therefore can be massive in 4-D sense: this allows to generalize twistor description to massive case [K12]. Secondly, standard SUSY characterizes the QFT description obtained by replacing many-sheeted space-time time with a slightly curved region of Minkowski space.

   Massless (in 4-D sense) right-handed neutrinos represent the sub-SUSY with minimal breaking induced by the mixing of right- and left handed neutrinos caused by the properties of the Kähler-Dirac gamma matrices for which mixing between M^4 and CP_2 gamma matrices takes place induced breaking of M^4 chirality serving as a signature for massivation.

3. R-parity conservation leading to strong predictions in the case of MSSM is broken since right-handed neutrino can transform to a left-handed one by a coupling induced by the mixing of M^4 and CP_2 type gamma matrices in the Kähler-Dirac gamma matrices. Sparticles can decay to neutrino and particles the life-times of super-partners are finite and there is no lightest sparticle. The right-handed neutrino generated in the decays of sparticles would transform to neutrinos and produce missing energy not traceable to stanard sources.

   The problem of missing missing energy, which is the basic difficulty of the standard SUSY at LHC, might therefore be encountered also in TGD framework. One possibly is that sparticles are dark in TGD sense so that they have non-standard value of Planck constant. In this case sparticles could have the same p-adic mass scale as particles but characteristic quantal time scales would be scaled up by $h_{eff}/h = n$.

It is clear that TGD does not predict standard space-time SUSY (Majorana spinors, etc.). Now it seems also feasible that TGD predicts a variant of space-time SUSY with Dirac fermions with conserved B and L and that it is generated by fermionic oscillator operators at the sting world sheets and has finite $\mathcal{N}$ even if the sub-algebra of conformal algebra annihilating physical statesf is sub-algebra of full algebra isomorphic to it.

TGD based SUSY differs would differ dramatically from the SUSY as it is usually understood and LHC could allow to decide whether the standard view or TGD view is nearer to truth. TGD could explain the failure of LHC to find space-time SUSY: for instance, sparticles could be dark in TGD sense although their mass scales could be same as for particles.

In the following I will describe the evolution of ideas related to SUSY in TGD framework: I however decided to save the reader from documentation of the worst wrong tracks.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. There are concept maps about topics related to the contents of the chapter prepared using CMAP realized as html files. Links to all CMAP files can be found at `http://tgdtheory.fi/cmaphtml.html` [L2]. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L3].

2 Does TGD Allow The Counterpart Of Space-Time Super-symmetry?

The question whether TGD allows space-time super-symmetry or something akin to it has been a longstanding problem. A considerable progress in the respect became possible with the better understanding of the Kähler-Dirac equation.

2.1 Kähler-Dirac Equation

Before continuing one must briefly summarize the recent view about Kähler-Dirac equation.

1. The localization of the induced spinor fields to 2-D string world sheets is crucial. It is demanded both by the well-definedness of em charge and by number theoretical constraints. Induced W boson fields must vanish, and the Frobenius integrability conditions guaranteeing that the K-D operator involves no covariant derivatives in directions normal to the string world sheet must be satisfied.

2. The Kähler-Dirac equation (or Kähler Dirac equation) reads as

$$D_K\Psi = 0 \ . \tag{2.1}$$

   in the interior of space-time surface. The boundary variation of K-D equation gives the term

$$\Gamma^n\Psi = 0 \tag{2.2}$$

   at the light-like orbits of partonic 2-surfaces. Clearly, Kähler-Dirac gamma matrix Γ^n in normal direction must be light-like or vanish.

3. To the boundaries of string world sheets at the orbits of partonic 2-surfaces one assigns 1-D Dirac action in induced metric line with length as bosonic counterpart. By field equations both actions vanish, and one obtains light-like geodesic carrying light-like 8-momentum. Algebraic variant of massless 8-D Dirac equation is satisfied for the 8-momentum parallel to 8-velocity.

   The boundaries of the string world sheets are thus pieces of light-like M^8 geodesics and different fermion lines should have more or less parallel M^4 momenta for the partonic 2-surface to preserve its size. This suggests strongly a connection with quantum field theory and an 8-D generalization of twistor Grassmannian approach encourages also by the very special twistorial properties of M^4 and CP_2.

   One can wonder how this relates to braiding which is one of the key ingredients of TGD. Is the braiding possible unless it is induced by particle exchanges so that the 8-momentum changes its direction and partonic 2-surface replicates. In principle it should be possible to construct the orbits of partonic 2-surfaces in such a manner that braiding occurs. Situation is the reverse of the usual in which one has fixed 3-manifold in which one constructs braid.

4. One can construct preferred extremals by starting from string world sheets satisfying the vanishing of normal components of canonical momentum currents as analogs of boundary conditions. One can also fix 3-D space-like surfaces and partonic orbits and pose the vanishing of super-symplectic charges for a sub-algebra with conformal weights coming as multiples of fixed integer n as conditions selecting preferred extremals.

5. The quantum numbers characterizing zero energy states couple directly to space-time geometry via the measurement interaction terms in Kähler action expressing the equality of classical conserved charges in Cartan algebra with their quantal counterparts for space-time surfaces in quantum superposition. This makes sense if classical charges parametrize zero modes. The localization in zero modes in state function reduction would be the WCW counterpart of state function collapse. Thermodynamics would naturally couple to the space-time geometry via the thermodynamical or quantum averages of the quantum numbers.

2.2 Development Of Ideas About Space-Time SUSY

Let us first summarize the recent overall view about space-time super-symmetry for TGD discussed in detail in chapter " WCW spinor structure" and also in [K15].

1. Right-handed covariantly constant neutrino spinor ν_R defines a super-symmetry in CP_2 degrees of freedom in the sense that CP_2 Dirac equation is satisfied by covariant constancy and there is no need for the usual ansatz $\Psi = D\Psi_0$ giving $D^2\Psi = 0$. This super-symmetry allows to construct solutions of Dirac equation in CP_2 [**?**, **?**, **?**, **?**].

2. In $M^4 \times CP_2$ this means the existence of massless modes $\Psi = \not{p}\Psi_0$, where Ψ_0 is the tensor product of M^4 and CP_2 spinors. For these solutions M^4 chiralities are not mixed unlike for all other modes which are massive and carry color quantum numbers depending on the CP_2 chirality and charge. As matter fact, massless right-handed neutrino covariantly constant in CP_2 spinor mode is the only color singlet. The mechanism leading to non-colored states for fermions is based on super-conformal representations for which the color is neutralized [K6, K9]. The negative conformal weight of the vacuum also cancels the enormous contribution to mass squared coming from mass in CP_2 degrees of freedom.

3. All spinor modes define conserved fermion super-currents and also the super-symplectic algebra has a fermion representation as Noether currents at string world sheets. WCW metric can be constructed as anti-commutators of super-symplectic Noether currents and one obtains a generalization of AdS/CFT duality to TGD framework from the possibility to express Kähler also in terms of Kähler function (and thus Kähler action). The fact that that super-Poincare anti-commutator vanishes for oscillator operators associated with covariantly constant right-handed neutrino and anti-neutrino implies that it corresponds to a pure gauge degree of freedom.

4. The natural conjecture is that the TGD analog space-time SUSY is generated by the Clifford algebra of the second quantized fermionic oscillator operators at string world sheets. This algebra in turn generalizes to Yangian. The oscillator operators indeed allow the 8-D analog of super-Poincare anti-commutation relations at the ends of 1-D light-like geodesics defined by the boundaries of string world sheets belonging to the orbits of partonic 2-surfaces and carrying 8-D light-like momentum.

   For incoming on mass shell particles one can identify the M^4 part of 8-momentum as gravitational for momentum equal to the inertial four-momentum assignable to imbedding space spinor harmonic for incoming on mass shell state. The square of E^4 momentum giving mass squared corresponds to the eigenvalue of CP_2 d'Alembertian.

   8-D light-like momentum forces an 8-D generalization of the twistor approach and M^4 and CP_2 are indeed unique in that they allow twistor space with Kähler structure [K12]. The conjecture is that integration over virtual momenta restricts virtual momenta to 8-D light-like momenta but the polarizations of virtual fermions are non-physical.

5. The 8-D generalization of SUSY describes also massive states and one has $\mathcal{N} = \infty$. Ordinary 4-D SUSY is obtained by restricting the states to the massless sector of the theory. The value of $\mathcal{N}$ is finite in this case and corresponds to the value of massless modes for fundamental fermions. Quark and lepton type spinor components with physical helicity for fermions and anti-fermions define the basis of the SUSY algebra as Clifford algebra of oscillator operators with anti-commutators analogous to those associated with super Poincare algebra. Therefore the generators of SUSY correspond to the $4+4$ components of imbedding space spinor modes

(quarks and leptons) with vanishing conformal weight so that analogs of $\mathcal{N}=4$ SUSY are obtained in quark and lepton sectors.

The SUSY is broken due to the electro-weak and color interactions between the fundamental fermions. For right-handed neutrinos these interactions are not present but the mixing with left handed neutrino due to the mixing of M^4 and CP_2 gamma matrices in Kähler-Dirac gamma matrices at string world sheets implies SUSY breaking also now: also R-parity is broken.

Basically a small mixing with the states with CP_2 mass is responsible for the generation of mass and breaking of SUSY. p-Adic thermodynamics describes this mixing. SUSY is broken at QFT limit also due the replacement of the many-sheeted space-time with single slightly curved region of M^4.

6. The SUSY in question is not the conventional $\mathcal{N}=1$ SUSY. Space-time (in the sense of Minkowski space M^4) $\mathcal{N}=1$ SUSY in the conventional sense of the word is impossible in TGD framework since it would require require Majorana spinors. In 8-D space-time with Minkowski signature of metric Majorana spinors are definitely ruled out by the standard argument leading to super string model. Majorana spinors would also break the separate conservation of lepton and baryon numbers in TGD framework. What is remarkable is that in 8-D space-time one obtains naturally SUSY with Dirac spinors.

2.3 Summary About TGD Counterpart Of Space-Time SUSY

This picture allows to define more precisely what one means with the approximate super-symmetries in TGD framework.

1. One can in principle construct many-fermion states containing both fermions and anti-fermions at fermion lines located at given light-like parton orbit. The four-momenta of states related by super-symmetry need not be same. Super-symmetry breaking is present and has as the space-time correlate the deviation of the Kähler-Dirac gamma matrices from the ordinary M^4 gamma matrices. In particular, the fact that $\hat{\Gamma}^\alpha$ possesses CP_2 part in general means that different M^4 chiralities are mixed: a space-time correlate for the massivation of the elementary particles.

2. For right-handed neutrino super-symmetry breaking is expected to be smallest but also in the case of the right-handed neutrino mode mixing of M^4 chiralities takes place and breaks the TGD counterpart of super-symmetry. Maybe the correct manner to interpret the situation is to speak about 8-D massless states for which the counterpart of SUSY would not be broken but mass splittings are possible.

3. The fact that all helicities in the state are physical for a given light-like 3-surface has important implications. For instance, the addition of a right-handed antineutrino to right-handed (left-handed) electron state gives scalar (spin 1) state. Also states with fermion number two are obtained from fermions. For instance, for e_R one obtains the states $\{e_R, e_R\nu_R\overline{\nu}_R, e_R\overline{\nu}_R, e_R\nu_R\}$ with lepton numbers $(1,1,0,2)$ and spins $(1/2,1/2,0,1)$. For e_L one obtains the states $\{e_L, e_L\nu_R\overline{\nu}_R, e_L\overline{\nu}_R, e_L\nu_R\}$ with lepton numbers $(1,1,0,2)$ and spins $(1/2,1/2,1,0)$. In the case of gauge boson and Higgs type particles -allowed by TGD but not required by p-adic mass calculations- gauge boson has 15 super partners with fermion numbers $[2,1,0,-1,-2]$.

The cautious conclusion is that the recent view about quantum TGD allows the analog of super-symmetry, which is necessary broken and for which the multiplets are much more general than for the ordinary super-symmetry. Right-handed neutrinos might however define something resembling ordinary super-symmetry to a high extent. The question is how strong prediction one can deduce using quantum TGD and proposed super-symmetry.

1. For a minimal breaking of super-symmetry only the p-adic length scale characterizing the super-partner differs from that for partner but the mass of the state is same. This would allow only a discrete set of masses for various super-partners coming as half octaves of the mass of the particle in question. A highly predictive model results.

2. The quantum field theoretic description could be based on QFT limit of TGD, which I have formulated in terms of bosonic emergence [K11]. The idea was that his formulation allows to calculate the propagators of the super-partners in terms of fermionic loops. Similar description of exchanged boson as fermionic loop emerges also in the proposed identification of scattering amplitudes as representations of algebraic computations in Yangian using product and co-product as fundamental vertices assignable to partonic 2-surfaces at which 3-surfaces replicate.

3. This TGD variant of space-time super-symmetry resembles ordinary super-symmetry in the sense that selection rules due to the right-handed neutrino number conservation and analogous to the conservation of R-parity hold true (the mixing of right-handed neutrino with the left-handed one breaks R-parity). The states inside super-multiplets have identical electro-weak and color quantum numbers but their p-adic mass scales can be different. It should be possible to estimate reaction reaction rates using rules very similar to those of super-symmetric gauge theories.

4. It might be even possible to find some simple generalization of standard super-symmetric gauge theory to get rough estimates for the reaction rates. There are however problems. The fact that spins $J = 0, 1, 2, 3/2, 2$ are possible for super-partners of gauge bosons forces to ask whether these additional states define an analog of non-stringy strong gravitation. Note that graviton in TGD framework corresponds to a pair of wormhole throats connected by flux tube (counterpart of string) and for gravitons one obtains 2^8-fold degeneracy.

2.4 SUSY Algebra Of Fermionic Oscillator Operators And WCW Local Clifford Algebra Elements As Super-fields

Whether TGD allows space-time supersymmetry has been a long-standing question. Majorana spinors appear in $N = 1$ super-symmetric QFTs- in particular minimally super-symmetric standard model (MSSM). Majorana-Weyl spinors appear in M-theory and super string models. An undesirable consequence is chiral anomaly in the case that the numbers of left and right handed spinors are not same. For $D = 11$ and $D = 10$ these anomalies cancel, which led to the breakthrough of string models and later to M-theory. The probable reason for considering these dimensions is that standard model does not predict right-handed neutrino (although neutrino mass suggests that right handed neutrino exists) so that the numbers of left and right handed Weyl-spinors are not the same.

In TGD framework the situation is different. Covariantly constant right-handed neutrino spinor acts as a super-symmetry in CP_2. One might think that right-handed neutrino in a well-defined sense disappears from the spectrum as a zero mode so that the number of right and left handed chiralities in $M^4 \times CP_2$ would not be same. For light-like 3-surfaces covariantly constant right-handed neutrino does not however solve the counterpart of Dirac equation for a non-vanishing four-momentum and color quantum numbers of the physical state. Therefore it does not disappear from the spectrum anymore and one expects the same number of right and left handed chiralities.

In TGD framework the separate conservation of baryon and lepton numbers excludes Majorana spinors and also the the Minkowski signature of $M^4 \times CP_2$ makes them impossible. The conclusion that TGD does not allow super-symmetry is however wrong. For $\mathcal{N} = 2N$ Weyl spinors are indeed possible and if the number of right and left handed Weyl spinors is same super-symmetry is possible. In 8-D context right and left-handed fermions correspond to quarks and leptons and since color in TGD framework corresponds to CP_2 partial waves rather than spin like quantum number, also the numbers of quark and lepton-like spinors are same.

The physical picture suggest a new kind of approach to super-symmetry in the sense that the anti-commutations of fermionic oscillator operators associated with the modes of the induced spinor fields define a structure analogous to SUSY algebra in 8-D sense. Massless modes of spinors in 1-1 corresponds with imbedding space spinors with physical helicity are in 1-1 correspondence with the generators of SUSY at space-time level giving $\mathcal{N} = 4 + 4$. Right handed neutrino modes define a sub-algebra for which the SUSY is only slightly broken by the absence of weak interactions and one could also consider a theory containing a large number of $\mathcal{N} = 2$ super-multiplets corresponding to the addition of right-handed neutrinos and antineutrinos at the wormhole throat.

Masslessness condition is essential if super-symmetric quantum field theories and at the fundamental level it can be generalized to masslessness in 8-D sense in terms of Kähler-Dirac gamma matrices using octonionic representation and assuming that they span local quaternionic sub-algebra at each point of the space-time sheet. SUSY algebra has standard interpretation with respect to spin and isospin indices only at the partonic 2-surfaces so that the basic algebra should be formulated at these surfaces: in fact, out that the formulation is needed only at the ends of fermion lines. Effective 2-dimensionality would require that partonic 2-surfaces can be taken to be ends of any light-like 3-surface Y_l^3 in the slicing of the region surrounding a given wormhole throat.

2.4.1 Super-algebra associated with the Kähler-Dirac action

Anti-commutation relations for fermionic oscillator operators associated with the induced spinor fields are naturally formulated in terms of the Kähler-Dirac gamma matrices. The canonical anti-commutation relations for the fermionic oscillator operators at light-like 3-surfaces or at their ends can be formulated as anti-commutation relations for SUSY algebra. The algebra creating physical states is super-symplectic algebra whose generators are expressed as Noether charges assignable to strings connecting partonic 2-surfaces.

Lepton and quark like spinors are now the counterparts of right and left handed Weyl spinors. Spinors with dotted and un-dotted indices correspond to conjugate representations of $SO(3,1) \times SU(4)_L \times SU(2)_R$. The anti-commutation relations make sense for sigma matrices identified as 6-dimensional matrices $1_6, \gamma_7, \gamma_1, ...\gamma_6$.

Consider first induced spinor fields at the boundaries of string world sheets at the orbits of wormhole throats. Dirac action for induced spinor fields and its bosonic counterpart defined by line-length are required by the condition that one obtains fermionic propagators massless in 8-D sense.

1. The localization of induced spinor fields to string world sheets and the addition of 1-D Dirac action at the boundaries of string world sheets at the orbits of partonic 2-surfaces reduces the quantization to that at the end of the fermion line at partonic 2-surface located at the boundary of CD. Therefore the situation reduces to that for point particle.

2. The boundary is by the extremization of line length a geodesic line of imbedding space, which can be characterized by conserved four-momentum and conserved angular momentum like charge - call it hypercharge Y. The square of 8-velocity vanishes: $v_4^2 - (v^\phi)^2 = 0$ and one can choose $v_4^2 = 1$. 8-momentum is proportional to 8-velocity expressible as (v^k, v^ϕ).

3. Dirac equation gives $\Gamma^t \partial_t \Psi = (\gamma_k v^k + \gamma_\phi) v^\phi) \partial_t \Psi = 0$. The non-trivial solution corresponds to $\partial_t \Psi = i\omega\Psi$ and the light-likeness condition. The value of parameter ω defines the mass scale and quantum classical correspondences suggests that ω^2 gives the mass squared identifiable as the eigenvalue of CP_2 Laplacian for spinor modes.

4. Anti-commutation relations must be fixed at either end of fermion line for the oscillator operators associated with the modes of induced spinor field at string world sheet labelled by integer value conformal weight and spin and weak isospin for the H-spinor involved. These anti-commutation relations must be consistent with standard canonical quantization allowing in turn to assign Noether charges to super-symplectic algebra defined as integrals over string world sheet. The identification of WCW gamma matrices as these charges allows to calculate WCW metric as their anti-commutators.

5. The oscillator operators for the modes with different values of conformal weight vanish. Standard anti-commutation relations in massive case are completely fixed and correspond to just Kronecker delta for conformal weights, spin, and isospin.

Space-time supersymmetry and the need to generalize 4-D twistors to 8-D ones suggest the anti-commutation relations obeyed by 8-D analogs of massless Weyl spinors and thus proportional to $p_8^k \sigma_k$, where p_8^k is the 8-momentum associated with the end of the fermion line and σ_k are the 8-D analogs of 2×2 sigma matrices.

1. This requires the introduction of octonionic spinor structure with gamma matrices represented in terms of octonionic units and introducing octonionic gamma matrices. The natural condition is that the octonionic gamma matrices are equivalent with the ordinary one. This is true if fermions are localied at time-like or light-like geodesic lines of imbedding space since they represent- not only quaternionic, but even hypercomplex sub-manifolds of imbedding space. This allows ordinary matrix representations for the gamma matrices at fermion lines.

2. One can avoid the problems with the non-associativity also at string world sheets possible caused by the Kähler Dirac gamma matrices if the two Kähler Dirac gamma matrices span commutative subspace of complexified octonions. The sigma matrices appearing in induced gauge potentials could be second source of non-associativity. By assuming that the solutions are holomorphic spinors (just as in string models) and that in the gauge chosen only holomorphic or anti-holomorphic components of gauge boson fields are non-vanishing, one avoids these problems.

3. It must be admitted that the constraints on string world sheets are strong: vanishing W induced gauge fields, Frobenius integrability conditions, and the condition that K-D gamma matrices span a commutative sub-space of complexified octonions, and I have not really proven that they can be satisfied.

The super-generators of space-time SUSY are proportional to fermionic oscillator operators obeying the canonical anti-commutation relations. It is not quite clear to me whether the proportionality constant can be taken to be equal to one although intuition suggests this strongly. The anti-commutations can contain only the light-like 8-velocity at the right hand side carrying information about the direction of the fermion line.

One can wonder in how strong sense the strong form of holography is realized.

1. Is the only information about the presence of strings at the level of scattering amplitudes the information coded by the anti-commutation relations at their end points? This would be the case if the fermion super-conformal charges vanish or create zero norm states for non-vanishing conformal weights. It could however happen that also the super-conformal generators associated with a sub-algebra of conformal algebra with weights coming as integer multiples of the entire algebra do this. At least this should be the case for the super-symplectic algebra.

2. Certainly one must assume that the 8-velocities associated with the ends of the fermionic string are independent so that strings would imply bi-locality of the dynamics.

2.4.2 Summing up the anti-commutation relations

In leptonic sector one would have the anti-commutation relations

$$\begin{aligned} \{a^{\dagger}_{m\dot{\alpha}}, a^n_{\beta}\} &= 2\delta^n_m D_{\dot{\alpha}\beta} \ , \\ D &= (p_\mu + \sum_a Q^a_\mu)\sigma^\mu \ . \end{aligned} \tag{2.3}$$

In quark sector σ^μ is replaced with $\overline{\sigma}^\mu$ obtained by changing the signs of space-like sigma matrices in leptonic sector. p_μ and Q^a_μ are the projections of momentum and color charges in Cartan algebra to the space-time surface and their values correspond to those assignable to the fermion line and related by quantum classical correspondence to those associated with incoming spinor harmonic.

The anti-commutation relations define a generalization of the ordinary equal-time anti-commutation relations for fermionic oscillator operators to a manifestly covariant form. Extended SUSY algebra suggest that the anti-commutators could contain additional central charge term proportional to $\delta_{\alpha\beta}$ but the 8-D chiral invariance excludes this term.

In the octonionic representation of the sigma matrices matrix indices cannot be present at the right handed side without additional conditions. Octonionic units however allow a representation as matrices defined by the structure constants failing only when products of more than two octonions are considered. For the quaternionic sub-algebra this does not occur. Both spinor modes and and gamma matrices must belong to the local hyper-quaternionic sub-algebra and do trivially so for fermion lines and string. Octonionic representation reduces $SO(7,1)$ so G_2 as a tangent space group. Similar reduction for 7-dimensional compact space takes place also M-theory.

In standard SUSY local super-fields having values in the Grassmann algebra generated by theta parameters appear. In TGD framework this would mean allowance of many-fermion states at single space-time point and this is perhaps too heavy an idealization since partonic 2-surfaces are the fundamental objects. Multi-stringy generators in the extension of super-symplectic algebra to Yangian is a more natural concept in TGD framework since one expects that partonic 2-surfaces involve several strings connecting them to other partonic 2-surfaces. Super-symplectic charges would be Noether charges assignable to these strings and quantum states would be created by these charges from vacuum. Scattering amplitudes would be defined in terms of Yangian algebra [K12]. Only at QFT limit one can hope that super-field formalism works.

3 Understanding Of The Role Of Right-Handed Neutrino In Supersymmetry

The development of the TGD view about space-time SUSY has been like a sequence of questions loves -doesn't love- loves.... From the beginning it was clear that right-handed neutrino could generate super-conformal symmetry of some kind, and the natural question was whether it generates also space-time SUSY. Later it became clear that all fermion oscillator operators can be interpreted as super generators for the analog of space-time SUSY. After that the challenge was to understand whether all spin-isospin states of fermions correspond super generators.

$\mathcal{N}=1$ SUSY was excluded by separate conservation of B and L but $\mathcal{N}=2$ variant of this symmetry could be considered and could be generated by massless right-handed neutrino and antineutrino mode.

The new element in the picture was the physical realization of the SUSY by adding fermions - in special case right-handed neutrino - to the state associated with the orbit of partonic 2-surface. An important realization was the necessity to localized spinors to string world sheet and the assignment of fernionic oscillator operator with boundaries of string world sheets at them. Variational principles implies that the fermions have light-like 8-momenta and that the fermion lines are light-like geodesics in 8-D sense. This leads to a precise view about the quantization of induced spinor fields. Fermionic oscillator operator algebra would generate Clifford algebra replacing the SUSY algebra and one would obtain the analog of super Poincare algebra from anti-commutation relations.

3.1 Basic Vision

As already explained, the precise meaning of SUSY in TGD framework has been a long-standing head ache. In TGD framework SUSY is inherited from super-conformal symmetry at the level of WCW [K3, K2]. The SUSY differs from $\mathcal{N}=1$ SUSY of the MSSM and from the SUSY predicted by its generalization and by string models. Allowing only right-handed neutrinos as SUSY generators, one obtains the analog of the $\mathcal{N}=4$ SUSY in bosonic sector but there are profound differences in the physical interpretation. The most general view is that all fermion modes with vanishing conformal weights define super charges.

1. One could understand SUSY in very general sense as an algebra of fermionic oscillator operators acting on vacuum states at partonic 2-surfaces. Oscillator operators are assignable to braids ends and generate fermionic many particle states. SUSY in this sense is badly broken and the algebra corresponds to rather large $\mathcal{N}$. The restriction to covariantly constant right-handed neutrinos (in CP_2 degrees of freedom) gives rise to the counterpart of ordinary SUSY, which is more physically interesting at this moment.

2. Right handed neutrino and antineutrino are not Majorana fermions. This is necessary for separate conservation of lepton and baryon numbers. For fermions one obtains the analog $\mathcal{N}=2$ SUSY.

3. Bosonic emergence [K11] means the construction of bosons as bound states of fermions and anti-fermions at opposite throats of wormhole contact. Later it became clear that all elementary particles emerge as bound states of fundamental fermions located at the wormhole throats of a pair of wormhole contacts. Two wormhole contacts are required by the assumption wormhole contacts carry monopole magnetic flux stabilizing them.

   This reduces TGD SUSY to that for fundamental fermions. This difference is fundamental and means deviation from the $\mathcal{N} = 4$ SUSY, where SUSY acts on gauge boson states. Bosonic representations are obtained as tensor products of representations assigned to the opposite throats of wormhole contacts. One can also have several fermion lines at given throat but these states are expected to be exotic.

   Further tensor products with representations associated with the wormhole ends of magnetic flux tubes are needed to construct physical particles. This represents a crucial difference with respect to standard approach, where one introduces at the fundamental level both fermions and bosons or gauge bosons as in $\mathcal{N} = 4$ SUSY. Fermionic $\mathcal{N} = 2$ representations are analogous to "short" $\mathcal{N} = 4$ representations for which one half of super-generators annihilates the states.

4. If stringy super-conformal symmetries act as gauge transformations, the analog of $\mathcal{N} = 4$ SUSY is obtained in both quark and lepton sector. This extends to $\mathcal{N} = 8$ SUSY if parton orbits can carry both quarks and leptons. Lepto-quark is the simplest state of this kind.

5. The introduction of both fermions and gauge bosons as fundamental particles leads in quantum gravity theories and string models to $d = 10$ condition for the target space, spontaneous compactification, and eventually to the landscape catastrophe.

   For a supersymmetric gauge theory (SYM) in d-dimensional Minkowski space the condition that the number of transversal polarization for gauge bosons given by $d - 2$ equals to the number of fermionic states made of Majorana fermions gives $d-2 = 2^k$, since the the number of fermionic spinor components is always power of 2.

   This allows only $d = 3, 4, 6, 10, 16, ...$ Also the dimensions $d + 1$ are actually possible since the number of spinor components for d and $d + 1$ is same for d even. This is the standard argument leading to super-string models and M-theory. It it lost - or better to say, one gets rid of it - if the basic fields include only fermion fields and bosonic states are constructed as the tensor products of fermionic states. This is indeed the case in TGD, where spontaneous compactification plays no role and bosons are emergent.

6. Spontaneous compactification leads in string model picture from $\mathcal{N} = 1$ SUSY in say $d = 10$ to $\mathcal{N} > 1$ SUSY in $d = 4$ since the fermionic multiplet reduces to a direct sum of fermionic multiplets in $d = 4$. In TGD imbedding space is not dynamical but fixed by internal consistency requirements, and also by the condition that the theory is consistent with the standard model symmetries. The identification of space-time as 4-surface makes the induced spinor field dynamical and the notion of many-sheeted space-time allows to circumvent the objections related to the fact that only 4 field like degrees of freedom are present.

3.2 What Is The Role Of The Right-Handed Neutrino?

Whether right-handed neutrinos generate a supersymmetry in TGD has been a long standing open question. $\mathcal{N} = 1$ SUSY is certainly excluded by fermion number conservation but already $\mathcal{N} = 2$ defining a "complexification" of $\mathcal{N} = 1$ SUSY is possible and could generate right-handed neutrino and its antiparticle. Right-handed neutrinos should however possess a non-vanishing light-like momentum since the fully covariantly constant right-handed neutrino generates zero norm states.

The general view about the preferred extremals of Kähler action and application of the conservation of em charge to the Kähler-Dirac equation have led to a rather detailed view about classical and TGD and allowed to build a bridge between general vision about super-conformal symmetries in TGD Universe and field equations. This vision is discussed in detail in [K15].

1. Many-sheeted space-time means that single space-time sheet need not be a good approximation for astrophysical systems. The GRT limit of TGD can be interpreted as obtained by lumping many-sheeted space-time time to Minkowski space with effective metric defined as sum M^4 metric and sum of deviations from M^4 metric for various space-time sheets involved [K14]. This effective metric should correspond to that of General Relativity and Einstein's equations would reflect the underlying Poincare invariance. Gravitational and cosmological constants follow as predictions and EP is satisfied.

2. The general structure of super-conformal representations can be understood: super-symplectic algebra is responsible for the non-perturbative aspects of QCD and determines also the ground states of elementary particles determining their quantum numbers. The hierarchy of breakings of conformal symmetry as gauge gauge symmetry would explain dark matter. The sub-algebra for which super-conformal symmetry remains gauge symmetry would be isomorphic to the original algebra and generated by generators for which conformal weight is multiple of integer $n = h_{eff}/h$. This would would be true for super-symplectic algebra at least and possible for all other conformal algebras involved.

3. Super-Kac-Moody algebras associated with isometries and holonomies dictate standard model quantum numbers and lead to a massivation by p-adic thermodynamics: the crucial condition that the number of tensor factors in Super-Virasoro represention is 5 is satisfied.

4. One can understand how the Super-Kac-Moody currents assignable to stringy world sheets emerging naturally from the conservation of em charge defined as their string world sheet Hodge duals gauge potentials for standard model gauge group and also their analogs for gravitons. Also the conjecture Yangian algebra generated by Super-Kac-Moody charges emerges naturally.

5. One also finds that right handed neutrino is in a very special role because of its lacking couplings in electroweak sector and its role as a generator of the least broken SUSY. The most feasible option is that all modes of the induced spinor field are restricted to 2-D string world sheets. If covariantly constant right-handed neutrino could be de-localized completely it cannot generate ordinary kind of gauge super-symmetry. It is not yet completely clear whether the modes of the induced spinor field are localized at string world sheets also inside the Euclidian wormhole contacts defining the lines of the generalized Feynman diagrams.

   Intermediate gauge boson decay widths require that sparticles are either heavy enough or dark in the sense of having non-standard value of Planck constant. Darkness would provide an elegant explanation for their non-observability. It should be emphasized that TGD predicts that all fermions act as generators of badly broken super-symmetries at partonic 2-surfaces but these super-symmetries could correspond to much higher mass scale as that associated with the de-localized right-handed neutrino. The following piece of text summarizes the argument.

6. Ordinary SUSY means that apart from kinematical spin factors sparticles and particles behave identically with respect to standard model interactions. These spin factors would allow to distinguish between particles and sparticles. This requires strong correlations between fermion and right-handed neutrino: in fact, they should be at rest with respect to each other. Right-handed neutrinos have vanishing color and electro-weak quantum numbers. How it is possible to have sparticles as bound states with ordinary particle and right-handed neutrino?

   The localization of induced spinor fields to string world sheets suggests a solution to the problem.

   (a) The localization forces the fermions to move in parallel although they have no interactions. The 8-momenta and 8-velocities of fermion are light-like and they move along light-like 8-geodesics. Since the size of the partonic 2-surface should not change much. If all fundamental fermions involved are massive one can assume that they are at rest and in this manner geometrically stable state.

(b) If one has massive fermion and massless right-handed neutrino, they should be at rest with respect to each other. What looks paradoxical that one cannot reduce the velocity to exactly zero in any coordinate system since covariantly constant right-handed neutrino represents a pure gauge degree of freedom. It is of course possible to assume that the relative velocity is some sufficiently low velocity. One can also argue that sparticles are unstable and that this is basically due to a geometric instability implied by the non-parallel 3-momenta of fundamental fermions.

(c) If one assumes that the 4-momentum squared corresponds to that associated with the imbedding space spinor harmonics, one can to estimate the mass of the sparticle once the energy of the right-handed neutrino is fixed. This argument applies also to n-fermion states at associated with the wormhole contact pairs.

(d) p-Adic mass calculations however give to mass squared also other contributions that that coming from the spinor harmonic, in particular negative ground state contribution and that the mass squared of the fundamental fermion vanishes for lowest states which would therefore have vanishing CP_2 velocity. Why the light-like four-momentum of the resulting state should not characterize the fermion line? In this picture p-adic thermal excitations would make the state unstable. One could in fact turn this argument to an explanation for why the the stable physical particles must parallel 4-momenta.

(e) What is still not well-understood is the tachyonic contribution to four-momentum. One possibility is that wormhole contact gives imaginary contribution to four-momentum. Second possibility is that the generating super-symplectic conformal weights are the negatives for the zeros of zeta. For non-trivial zeros the real part of the conformal would be -1/2.

So called massless extremals (MEs) define massless represent classical field pattern moving with light velocity and preserving its shape. This suggests that particle represented as a magnetic flux tube structure carrying monopole flux with two wormhole contacts and sliced between two MEs could serve as a starting point in attempts to understand the role of right handed neutrinos and how $\mathcal{N}=2$ or $\mathcal{N}=4$ type SYM emerges at the level of space-time geometry.

3.3 The Impact From LHC And Evolution Of TGD Itself

The missing energy predicted standard SUSY seems to be absent at LHC. The easy explanation would be that the mass scale of SUSY is unexpectedly high, of order 1-10 TeV. This would however destroy the original motivations for SUSY. The arguments developed in the following manner.

1. One must distinguish between imbedding space spinor harmonics and the modes of the induced spinor field. Right-handed neutrino with vanishing color quantum numbers and thus covariantly constant in CP_2 is massless. All other modes of the induced spinor field are massive and in according to the p-adic mass calculations negative conformal weight of the ground state and the presence of Kac-Moody and super-symplectic generators make possible massless states having thermal excitations giving to the state a thermal mass. Right-handed neutrino can mix with left-handed neutrino ad can get mass. One can assign to any fermion a super-multiplet with 4 members.

   One cannot assign full super-4-plet also to non-colored right handed neutrino itself: the multiplet would contain only 3 states. The most natural possibility is that the ground state is now a color excitation of right-handed neutrino and massless non-colored right-handed neutrinos give rise to the 4-plet. The colored spinor mode at imbedding space level is however a mixture or left- and right handed neutrinos.

2. In TGD framework the natural first guess is that right-handed neutrinos carrying four-momentum can give rise to missing energy. The assumption that fermions correspond to color partial waves in H implies that color excitations of the right handed neutrino that would appear in asymptotic states are necessarily colored. It could happen that these excitations are color neutralized by super-conformal generators. If this is not the case, these neutrinos would be like quarks and color confinement would explain why they cannot be observed as asymptotic states in macroscopic scales.

Second possibility is that SUSY itself is generated by color partial waves of right-handed neutrino, octet most naturally. This option is however not consistent with the above model for one-fermion states and their super-partners.

3.4 Supersymmetry In Crisis

Supersymmetry is very beautiful generalization of the ordinary symmetry concept by generalizing Lie-algebra by allowing grading such that ordinary Lie algebra generators are accompanied by super-generators transforming in some representation of the Lie algebra for which Lie-algebra commutators are replaced with anti-commutators. In the case of Poincare group the super-generators would transform like spinors. Clifford algebras are actually super-algebras. Gamma matrices anti-commute to metric tensor and transform like vectors under the vielbein group (SO(n) in Euclidian signature). In supersymmetric gauge theories one introduced super translations anti-commuting to ordinary translations.

Supersymmetry algebras defined in this manner are characterized by the number of super-generators and in the simplest situation their number is one: one speaks about $\mathcal{N}=1$ SUSY and minimal super-symmetric extension of standard model (MSSM) in this case. These models are most studied because they are the simplest ones. They have however the strange property that the spinors generating SUSY are Majorana spinors- real in well-defined sense unlike Dirac spinors. This implies that fermion number is conserved only modulo two: this has not been observed experimentally. A second problem is that the proposed mechanisms for the breaking of SUSY do not look feasible.

LHC results suggest MSSM does not become visible at LHC energies. This does not exclude more complex scenarios hiding simplest $\mathcal{N}=1$ to higher energies but the number of real believers is decreasing. Something is definitely wrong and one must be ready to consider more complex options or totally new view abot SUSY.

What is the analog of SUSY in TGD framework? I must admit that I am still fighting to gain understanding of SUSY in TGD framework [K16]. That I can still imagine several scenarios shows that I have not yet completely understood the problem but I am working hardly to avoid falling to the sin of sloppying myself.

At the basic level one has super-conformal invariance generated in the fermion sector by the super-conformal charges assignable to the strings emanating from partonic 2-surfaces and connecting them to each other. For elementary particles one has 2 wormhole contacts and 4 wormhole throats. If the number of strings is just one, one has symplectic super-conformal symmetry, which is already huge. Several strings must be allowed and this leads to the Yangian variant of super-conformal symmetry, which is multi-local (multi-stringy).

One can also say that fermionic oscillator operators generate infinite-D super-algebra. One can restrict the consideration to lowest conformal weights if spinorial super-conformal invariance acts as gauge symmetry so that one obtains a finite-D algebra with generators labelled by electro-weak quantum numbers of quarks and leptons. This super-symmetry is badly broken but contains the algebra generated by right-handed neutrino and its conjugate as sub-algebra.

The basic question is whether covariantly constant right handed neutrino generators $\mathcal{N}=\in$ SUSY or whether the SUSY is generated as approximate symmetry by adding massless right-handed neutrino to the state thus changing its four-momentum. The problem with the first option is that it the standard norm of the state is naturally proportional to four-momentum and vanishes at the limit of vanishing four-momentum: is it possible to circumvent this problem somehow? In the following I summarize the situation as it seems just now.

1. In TGD framework $\mathcal{N}=1$ SUSY is excluded since B and L and conserved separately and imbedding space spinors are not Majorana spinors. The possible analog of space-time SUSY should be a remnant of a much larger super-conformal symmetry in which the Clifford algebra generated by fermionic oscillator operators giving also rise to the Clifford algebra generated by the gamma matrices of the "world of classical worlds" (WCW) and assignable with string world sheets. This algebra is indeed part of infinite-D super-conformal algebra behind quantum TGD. One can construct explicitly the conserved super conformal charges accompanying ordinary charges and one obtains something analogous to $\mathcal{N}=\infty$ super algebra. This SUSY is however badly broken by electroweak interactions.

2. The localization of induced spinors to string world sheets emerges from the condition that electromagnetic charge is well-defined for the modes of induced spinor fields. There is however an exception: covariantly constant right handed neutrino spinor ν_R: it can be de-localized along entire space-time surface. Right-handed neutrino has no couplings to electroweak fields. It couples however to left handed neutrino by induced gamma matrices except when it is covariantly constant. Note that standard model does not predict ν_R but its existence is necessary if neutrinos develop Dirac mass. ν_R is indeed something which must be considered carefully in any generalization of standard model.

3.4.1 *Could covariantly constant right handed neutrinos generate SUSY?*

Could covariantly constant right-handed spinors generate exact $\mathcal{N} = 2$ SUSY? There are two spin directions for them meaning the analog $\mathcal{N} = 2$ Poincare SUSY. Could these spin directions correspond to right-handed neutrino and antineutrino. This SUSY would not look like Poincare SUSY for which anti-commutator of super generators would be proportional to four-momentum. The problem is that four-momentum vanishes for covariantly constant spinors! Does this mean that the sparticles generated by covariantly constant ν_R are zero norm states and represent super gauge degrees of freedom? This might well be the case although I have considered also alternative scenarios.

3.4.2 *What about non-covariantly constant right-handed neutrinos?*

Both imbedding space spinor harmonics and the Kähler-Dirac equation have also right-handed neutrino spinor modes not constant in M^4 and localized to the partonic orbits. If these are responsible for SUSY then SUSY is broken.

1. Consider first the situation at space-time level. Both induced gamma matrices and their generalizations to Kähler-Dirac gamma matrices defined as contractions of imbedding space gamma matrices with the canonical momentum currents for Kähler action are superpositions of M^4 and CP_2 parts. This gives rise to the mixing of right-handed and left-handed neutrinos. Note that non-covariantly constant right-handed neutrinos must be localized at string world sheets.

   This in turn leads neutrino massivation and SUSY breaking. Given particle would be accompanied by sparticles containing varying number of right-handed neutrinos and antineutrinos localized at partonic 2-surfaces.

2. One an consider also the SUSY breaking at imbedding space level. The ground states of the representations of extended conformal algebras are constructed in terms of spinor harmonics of the imbedding space and form the addition of right-handed neutrino with non-vanishing four-momentum would make sense. But the non-vanishing four-momentum means that the members of the super-multiplet cannot have same masses. This is one manner to state what SUSY breaking is.

3.4.3 *What one can say about the masses of sparticles?*

The simplest form of massivation would be that all members of the super-multiplet obey the same mass formula but that the p-adic length scales associated with them are different. This could allow very heavy sparticles. What fixes the p-adic mass scales of sparticles? If this scale is CP_2 mass scale SUSY would be experimentally unreachable. The estimate below does not support this option.

One can consider the possibility that SUSY breaking makes sparticles unstable against phase transition to their dark variants with $h_{eff} = n \times h$. Sparticles could have same mass but be non-observable as dark matter not appearing in same vertices as ordinary matter! Geometrically the addition of right-handed neutrino to the state would induce many-sheeted covering in this case with right handed neutrino perhaps associated with different space-time sheet of the covering.

This idea need not be so outlandish at it looks first.

1. The generation of many-sheeted covering has interpretation in terms of breaking of conformal invariance. The sub-algebra for which conformal weights are n-tuples of integers becomes the algebra of conformal transformations and the remaining conformal generators do note represent gauge degrees of freedom anymore. They could however represent conserved conformal charges still.

2. This generalization of conformal symmetry breaking gives rise to infinite number of fractal hierarchies formed by sub-algebras of conformal algebra and is also something new and a fruit of an attempt to avoid sloppy thinking. The breaking of conformal symmetry is indeed expected in massivation related to the SUSY breaking.

The following poor man's estimate supports the idea about dark sfermions and the view that sfermions cannot be very heavy.

1. Neutrino mixing rate should correspond to the mass scale of neutrinos known to be in eV range for ordinary value of Planck constant. For $h_{eff}/h = n$ it is reduced by factor $1/n$, when mass kept constant. Hence sfermions could be stabilized by making them dark.

2. A very rough order of magnitude estimate for sfermion mass scale is obtained from Uncertainty Principle: particle mass should be higher than its decay rate. Therefore an estimate for the decay rate of sfermion could give a lower bound for its mass scale.

3. Assume the transformation $\nu_R \rightarrow \nu_L$ makes sfermion unstable against the decay to fermion and ordinary neutrino. If so, the decay rate would be dictated by the mixing rate and therefore to neutrino mass scale for the ordinary value of Planck constant. Particles and sparticles would have the same p-adic mass scale. Large h_{eff} could however make sfermion dark, stable, and non-observable.

3.4.4 *A rough model for the neutrino mixing in TGD framework*

The mixing of neutrinos would be the basic mechanism in the decays of sfermions. The following argument tries to capture what is essential in this process.

1. Conformal invariance requires that the string ends at which fermions are localized at wormhole throats are light-like curves. In fact, light-likeness gives rise to Virasosoro conditions.

2. Mixing is described by a vertex residing at partonic surface at which two partonic orbits join. Localization of fermions to string boundaries reduces the problem to a problem completely analogous to the coupling of point particle coupled to external gauge field. What is new that orbit of the particle has edge at partonic 2-surface. Edge breaks conformal invariance since one cannot say that curve is light-like at the edge. At edge neutrino transforms from right-handed to left handed one.

3. In complete analogy with $\overline{\Psi}\gamma^t A_t \Psi$ vertex for the point-like particle with spin in external field, the amplitude describing $nu_R - \nu_L$ transition involves matrix elements of form $\overline{\nu}_R \Gamma^t(CP_2) Z_t \nu_L$ at the vertex of the CP_2 part of the Kähler-Dirac gamma matrix and classical Z^0 field.

   How Γ^t is identified? The Kähler-Dirac gamma matrices associated with the interior need not be well-defined at the light-like surface and light-like curve. One basis of weak form of electric magnetic duality the Kähler-Dirac gamma matrix corresponds to the canonical momentum density associated with the Chern-Simons term for Kähler action. This gamma matrix contains only the CP_2 part.

The following provides as more detailed view.

1. Let us denote by $\Gamma^t_{CP_2}(in/out)$ the CP_2 part of the Kähler-Dirac gamma matrix at string at at partonic 2-surface and by Z^0_t the value of Z^0 gauge potential along boundary of string world sheet. The direction of string line in imbedding space changes at the partonic 2-surface. The question is what happens to the Kähler-Dirac action at the vertex.

2. For incoming and outgoing lines the equation

$$D(in/out)\Psi(in/out) = p^k(in,out)\gamma_k\Psi(in/out) \ ,$$

where the Kähler-Dirac operator is $D(in/out) = \Gamma^t(in/out)D_t$, is assumed. ν_R corresponds to "in" and ν_R to "out". It implies that lines corresponds to massless M^4 Dirac propagator and one obtains something resembling ordinary perturbation theory.

It also implies that the residue integration over fermionic internal momenta gives as a residue massless fermion lines with non-physical helicities as one can expect in twistor approach. For physical particles the four-momenta are massless but in complex sense and the imaginary part comes classical from four-momenta assignable to the lines of generalized Feynman diagram possessing Euclidian signature of induced metric so that the square root of the metric determinant differs by imaginary unit from that in Minkowskian regions.

3. In the vertex $D(in/out)$ could act in $\Psi(out/in)$ and the natural idea is that $\nu_R - \nu_L$ mixing is due to this so that it would be described the classical weak current couplings $\overline{\nu}_R\Gamma^t_{CP_2}(out)Z^0_t(in)\nu_L$ and $\overline{\nu}_R\Gamma^t_{CP_2}(out)Z^0_t(in)\nu_L$.

To get some idea about orders of magnitude assume that the CP_2 projection of string boundary is geodesic circle thus describable as $\Phi = \omega t$, where Φ is angle coordinate for the circle and t is Minkowski time coordinate. The contribution of CP_2 to the induced metric g_{tt} is $\Delta g_{tt} = -R^2\omega^2$.

1. In the first approximation string end is a light-like curve in Minkowski space meaning that CP_2 contribution to the induced metric vanishes. Neutrino mixing vanishes at this limit.

2. For a non-vanishing value of ωR the mixing and the order of magnitude for mixing rate and neutrino mass is expected to be $R \sim \omega$ and $m \sim \omega/h$. p-Adic length scale hypothesis and the experimental value of neutrino mass allows to estimate m to correspond to p-adic mass to be of order eV so that the corresponding p-adic prime p could be $p \simeq 2^{167}$. Note that $k = 127$ defines largest of the four Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$ appearing in the length scale range 10 nm -2.5 μm. Hence the decay rate for ordinary Planck constant would be of order $R \sim 10^{14}$/s but large value of Planck constant could reduced it dramatically. In living matter reductions by a factor 10^{-12} can be considered.

To sum up, the space-time SUSY in TGD sense would differ crucially from SUSY in the standard sense. There would no Majorana spinors and sparticles could correspond to dark phase of matter with non-standard value of Planck constant. The signatures of the standard SUSY do not apply to TGD. Of course, a lot of professional work would be needed to derive the signatures of TGD SUSY.

3.5 Right-Handed Neutrino As Inert Neutrino?

There is a very interesting posting by Jester in Resonaances with title How many neutrinos in the sky? [C2]. Jester tells about the recent 9 years WMAP data [C21] and compares it with earlier 7 years data. In the earlier data the effective number of neutrino types was $N_{eff} = 4.34 \pm 0.87$ and in the recent data it is $N_{eff} = 3.26 \pm 0.35$. WMAP alone would give $N_{eff} = 3.89 \pm 0.67$ also in the recent data but also other data are used to pose constraints on N_{eff}.

To be precise, N_{eff} could include instead of fourth neutrino species also some other weakly interacting particle. The only criterion for contributing to N_{eff} is that the particle is in thermal equilibrium with other massless particles and thus contributes to the density of matter considerably during the radiation dominated epoch.

Jester also refers to the constraints on N_{eff} from nucleosynthesis, which show that $N_{eff} \sim 4$ us slightly favored although the entire range $[3,5]$ is consistent with data.

It seems that the effective number of neutrinos could be 4 instead of 3 although latest WMAP data combined with some other measurements favor 3. Later a corrected version of the eprint appeared [C21] telling that the original estimate of N_{eff} contained a mistake and the correct estimate is $N_{eff} = 3.84 \pm 0.40$.

An interesting question is what $N_{eff} = 4$ could mean in TGD framework?

1. One poses to the modes of the Kähler-Dirac equation the following condition: electric charge is conserved in the sense that the time evolution by Kähler-Dirac equation does not mix a mode with a well-defined em charge with those with different em charge. The implication is that all modes except pure right handed neutrino are restricted at string world sheets. The first guess is that string world sheets are minimal surfaces of space-time surface (rather than those of imbedding space). One can also consider minimal surfaces of imbedding space but with effective metric defined by the anti-commutators of the Kähler-Dirac gamma matrices. This would give a direct physical meaning for this somewhat mysterious effective metric.

   For the neutrino modes localized at string world sheets mixing of left and right handed modes takes place and they become massive. If only 3 lowest genera for partonic 2-surfaces are light, one has 3 neutrinos of this kind. The same applies to all other fermion species. The argument for why this could be the case relies on simple observation [K1]: the genera g=0, 1, 2 have the property that they allow for all values of conformal moduli Z_2 as a conformal symmetry (hyper-ellipticity). For $g > 2$ this is not the case. The guess is that this additional conformal symmetry is the reason for lightness of the three lowest genera.

2. Only purely right-handed neutrino is completely de-localized in 4-volume so that one cannot assign to it genus of the partonic 2-surfaces as a topological quantum number and it effectively gives rise to a fourth neutrino very much analogous to what is called sterile neutrino. De-localized right-handed neutrinos couple only to gravitation and in case of massless extremals this forces them to have four-momentum parallel to that of ME: only massless modes are possible. Very probably this holds true for all preferred extremals to which one can assign massless longitudinal momentum direction which can vary with spatial position.

3. The coupling of ν_R is to gravitation alone and all electroweak and color couplings are absent. According to standard wisdom de-localized right-handed neutrinos cannot be in thermal equilibrium with other particles. This according to standard wisdom. But what about TGD?

   One should be very careful here: de-localized right-handed neutrinos is proposed to give rise to SUSY (not $\mathcal{N} = 1$ requiring Majorana fermions) and their dynamics is that of passive spectator who follows the leader. The simplest guess is that the dynamics of right handed neutrinos at the level of amplitudes is completely trivial and thus trivially supersymmetric. There are however correlations between four-momenta.

   (a) The four-momentum of ν_R is parallel to the light-like momentum direction assignable to the massless extremal (or more general preferred extremal). This direct coupling to the geometry is a special feature of the Kähler-Dirac operator and thus of sub-manifold gravity.

   (b) On the other hand, the sum of massless four-momenta of two parallel pieces of preferred extremals is the - in general massive - four-momentum of the elementary particle defined by the wormhole contact structure connecting the space-time sheets (which are glued along their boundaries together since this is seems to be the only manner to get rid of boundary conditions requiring vacuum extremal property near the boundary). Could this direct coupling of the four-momentum direction of right-handed neutrino to geometry and four-momentum directions of other fermions be enough for the right handed neutrinos to be counted as a fourth neutrino species in thermal equilibrium? This might be the case!

   One cannot of course exclude the coupling of 2-D neutrino at string world sheets to 4-D purely right handed neutrinos analogous to the coupling inducing a mixing of sterile neutrino with ordinary neutrinos. Also this could help to achieve the thermal equilibrium with 2-D neutrino species.

3.6 Experimental Evidence For Sterile Neutrino?

Many physicists are somewhat disappointed to the results from LHC: the expected discovery of Higgs has been seen as the main achievement of LHC hitherto. Much more was expected. To my opinion there is no reason for disappointment. The exclusion of the standard SUSY at expected energy scale is very far reaching negative result. Also the fact that Higgs mass is too small to be stable without fine tuning is of great theoretical importance. The negative results concerning heavy dark matter candidates are precious guidelines for theoreticians. The non-QCD like behavior in heavy ion collisions and proton-ion collisions is bypassed my mentioning something about AdS/CFT correspondence and non-perturbative QCD effects. I tend to see these effects as direct evidence for M_{89} hadron physics [K7].

In any case, something interesting has emerged quite recently. Resonaances tells that the recent analysis [C19] of X-ray spectrum of galactic clusters claims the presence of monochromatic 3.5 keV photon line. The proposed interpretation is as a decay product of sterile 7 keV neutrino transforming first to a left-handed neutrino and then decaying to photon and neutrino via a loop involving W boson and electron. This is of course only one of the many interpretations. Even the existence of line is highly questionable.

One of the poorly understood aspects of TGD is right-handed neutrino, which is obviously the TGD counterpart of the inert neutrino.

1. The old idea is that covariantly constant right handed neutrino could generate $\mathcal{N} = 2$ supersymmetry in TGD Universe. In fact, all modes of induced spinor field would generate superconformal symmetries but electroweak interactions would break these symmetries for the modes carrying non-vanishing electroweak quantum numbers: they vanish for ν_R. This picture is now well-established at the level of WCW geometry [K17]: super-conformal generators are labelled angular momentum and color representations plus two conformal weights: the conformal weight assignable to the light-like radial coordinate of light-cone boundary and the conformal weight assignable to string coordinate. It seems that these conformal weights are independent. The third integer labelling the states would label genuinely Yangian generators: it would tell the poly-locality of the generator with locus defined by partonic 2-surface: generators acting on single partonic 2-surface, 2 partonic 2-surfaces, ...

2. It would seem that even the SUSY generated by ν_R must be badly broken unless one is able to invent dramatically different interpretation of SUSY. The scale of SUSY breaking and thus the value of the mass of right-handed neutrino remains open also in TGD. In lack of better one could of course argue that the mass scale must be CP_2 mass scale because right-handed neutrino mixes considerably with the left-handed neutrino (and thus becomes massive) only in this scale. But why this argument does not apply also to left handed neutrino which must also mix with the right-handed one!

3. One can of course criticize the proposed notion of SUSY: wonder whether fermion + extremely weakly interacting ν_R at same wormhole throat (or interior of 3-surface) can behave as single coherent entity as far spin is considered [K16] ?

4. The condition that the modes of induced spinor field have a well-defined electromagnetic charge eigenvalue [K15] requires that they are localized at 2-D string world sheets or partonic 2-surfaces: without this condition classical W boson fields would mix the em charged and neutral modes with each other. Right-handed neutrino is an exception since it has no electroweak couplings. Unless right-handed neutrino is covariantly constant, the Kähler-Dirac gamma matrices can however mix the right-handed neutrino with the left handed one and this can induce transformation to charged mode. This does not happen if each Kähler-Dirac gamma matrix can be written as a linear combination of either M^4 or CP_2 gamma matrices and Kähler-Dirac equation is satisfied separately by M^4 and CP_2 parts of the Kähler-Dirac equation.

5. Is the localization of the modes other than covariantly constant neutrino to string world sheets a consequence of dynamics or should one assume this as a separate condition? If one wants similar localization in space-time regions of Euclidian signature - for which CP_2 type vacuum extremal is a good representative - one must assume it as a separate condition. In number theoretic formulation string world sheets/partonic 2-surfaces would be commutative/co-commutative sub-manifolds of space-time surfaces which in turn would be associative or co-associative sub-manifolds of imbedding space possessing (hyper-)octonionic

tangent space structure. For this option also right-handed neutrino would be localized to string world sheets. Right-handed neutrino would be covariantly constant only in 2-D sense.

One can consider the possibility that ν_R is de-localized to the entire 4-D space-time sheet. This would certainly modify the interpretation of SUSY since the number of degrees of freedom would be reduced for ν_R.

6. Non-covariantly constant right-handed neutrinos could mix with left-handed neutrinos but not with charged leptons if the localization to string world sheets is assumed for modes carrying non-vanishing electroweak quantum numbers. This would make possible the decay of right-handed to neutrino plus photon, and one cannot exclude the possibility that ν_R has mass 7 keV.

   Could this imply that particles and their spartners differ by this mass only? Could it be possible that practically unbroken SUSY could be there and we would not have observed it? Could one imagine that sfermions have annihilated leaving only states consisting of fundamental fermions? But shouldn't the total rate for the annihilation of photons to hadrons be two times the observed one? This option does not sound plausible.

   What if one assumes that given sparticle is charactrized by the same p-adic prime as corresponding particle but is dark in the sense that it corresponds to non-standard value of Planck constant. In this case sfermions would not appear in the same vertex with fermions and one could escape the most obvious contradictions with experimental facts. This leads to the notion of shadron: shadrons would be [K16] obtained by replacing quarks with dark squarks with nearly identical masses. I have asked whether so called X and Y bosons having no natural place in standard model of hadron could be this kind of creatures.

The interpretation of 3.5 keV photons as decay products of right-handed neutrinos is of course totally ad hoc. Another TGD inspired interpretation would be as photons resulting from the decays of excited nuclei to their ground state.

1. Nuclear string model [K8] predicts that nuclei are string like objects formed from nucleons connected by color magnetic flux tubes having quark and antiquark at their ends. These flux tubes are long and define the "magnetic body" of nucleus. Quark and antiquark have opposite em charges for ordinary nuclei. When they have different charges one obtains exotic state: this predicts entire spectrum of exotic nuclei for which statistic is different from what proton and neutron numbers deduced from em charge and atomic weight would suggest. Exotic nuclei and large values of Planck constant could make also possible cold fusion [K4].

2. What the mass difference between these states is, is not of course obvious. There is however an experimental finding [C22] (see *Analysis of Gamma Radiation from a Radon Source: Indications of a Solar Influence*) that nuclear decay rates oscillate with a period of year and the rates correlate with the distance from Sun. A possible explanation is that the gamma rays from Sun in few keV range excite the exotic nuclear states with different decay rate so that the average decay rate oscillates [K8]. Note that nuclear excitation energies in keV range would also make possible interaction of nuclei with atoms and molecules.

3. This allows to consider the possibility that the decays of exotic nuclei in galactic clusters generates 3.5 keV photons. The obvious question is why the spectrum would be concentrated at 3.5 keV in this case (second question is whether the energy is really concentrated at 3.5 keV: a lot of theory is involved with the analysis of the experiments). Do the energies of excited states depend on the color bond only so that they would be essentially same for all nuclei? Or does single excitation dominate in the spectrum? Or is this due to the fact that the thermal radiation leaking from the core of stars excites predominantly single state? Could $E = 3.5$ keV correspond to the maximum intensity for thermal radiation in stellar core? If so, the temperature of the exciting radiation would be about $T \simeq E/3 \simeq 1.2 \times 10^7$ K. This in the temperature around which formation of Helium by nuclear fusion has begun: the temperature at solar core is around 1.57×10^7 K.

3.7 Delicacies of the induced spinor structure and SUSY mystery

The discussion of induced spinor structure leads to a modification of an earlier idea (one of the many) about how SUSY could be realized in TGD in such a manner that experiments at LHC energies could not discover it and one should perform experiments at the other end of energy spectrum at energies which correspond to the thermal energy about .025 eV at room temperature. I have the feeling that this observation could be of crucial importance for understanding of SUSY.

3.7.1 Induced spinor structure

The notion of induced spinor field deserves a more detailed discussion. Consider first induced spinor structures.

1. Induced spinor field are spinors of $M^4 \times CP_2$ for which modes are characterized by chirality (quark or lepton like) and em charge and weak isospin.

2. Induced spinor spinor structure involves the projection of gamma matrices defining induced gamma matrices. This gives rise to superconformal symmetry if the action contains only volume term.

   When Kähler action is present, superconformal symmetry requires that the modified gamma matrices are contractions of canonical momentum currents with imbedding space gamma matrices. Modified gammas appear in the modified Dirac equation and action, whose solution at string world sheets trivializes by super-conformal invariance to same procedure as in the case of string models.

3. Induced spinor fields correspond to two chiralities carrying quark number and lepton number. Quark chirality does not carry color as spin-like quantum number but it corresponds to a color partial wave in CP_2 degrees of freedom: color is analogous to angular momentum. This reduces to spinor harmonics of CP_2 describing the ground states of the representations of super-symplectic algebra.

   The harmonics do not satisfy correct correlation between color and electroweak quantum numbers although the triality t=0 for leptonic waves and t=1 for quark waves. There are two manners to solve the problem.

   (a) Super-symplectic generators applied to the ground state to get vanishing ground states weight instead of the tachyonic one carry color and would give for the physical states correct correlation: leptons/quarks correspond to the same triality zero(one partial wave irrespective of charge state. This option is assumed in p-adic mass calculations [K6].

   (b) Since in TGD elementary particles correspond to pairs of wormhole contacts with weak isospin vanishing for the entire pair, one must have pair of left and right-handed neutrinos at the second wormhole throat. It is possible that the anomalous color quantum numbers for the entire state vanish and one obtains the experimental correlation between color and weak quantum numbers. This option is less plausible since the cancellation of anomalous color is not local as assume in p-adic mass calculations.

The understanding of the details of the fermionic and actually also geometric dynamics has taken a long time. Super-conformal symmetry assigning to the geometric action of an object with given dimension an analog of Dirac action allows however to fix the dynamics uniquely and there is indeed dimensional hierarchy resembling brane hierarchy.

1. The basic observation was following. The condition that the spinor modes have well-defined em charge implies that they are localized to 2-D string world sheets with vanishing W boson gauge fields which would mix different charge states. At string boundaries classical induced W boson gauge potentials guarantee this. Super-conformal symmetry requires that this 2-surface gives rise to 2-D action which is area term plus topological term defined by the flux of Kähler form.

2. The most plausible assumption is that induced spinor fields have also interior component but that the contribution from these 2-surfaces gives additional delta function like contribution: this would be analogous to the situation for branes. Fermionic action would be accompanied by an area term by supersymmetry fixing modified Dirac action completely once the bosonic actions for geometric object is known. This is nothing but super-conformal symmetry.

   One would actually have the analog of brane-hierarchy consisting of surfaces with dimension D= 4,3,2,1 carrying induced spinor fields which can be regarded as independent dynamical variables and characterized by geometric action which is D-dimensional analog of the action for Kähler charged point particle. This fermionic hierarchy would accompany the hierarchy of geometric objects with these dimensions and the modified Dirac action would be uniquely determined by the corresponding geometric action principle (Kähler charged point like particle, string world sheet with area term plus Kähler flux, light-like 3-surface with Chern-Simons term, 4-D space-time surface with Kähler action).

3. This hierarchy of dynamics is consistent with SH only if the dynamics for higher dimensional objects is induced from that for lower dimensional objects - string world sheets or maybe even their boundaries orbits of point like fermions. Number theoretic vision [K18] suggests that this induction relies algebraic continuation for preferred extremals. Note that quaternion analyticity [K19] means that quaternion analytic function is determined by its values at 1-D curves.

4. Quantum-classical correspondences (QCI) requires that the classical Noether charges are equal to the eigenvalues of the fermionic charges for surfaces of dimension $D = 0, 1, 2, 3$ at the ends of the CDs. These charges would not be separately conserved. Charges could flow between objects of dimension $D + 1$ and D - from interior to boundary and vice versa. Four-momenta and also other charges would be complex as in twistor approach: could complex values relate somehow to the finite life-time of the state?

   If quantum theory is square root of thermodynamics as zero energy ontology suggests, the idea that particle state would carry information also about its life-time or the time scale of CD to which is associated could make sense. For complex values of α_K there would be also flow of canonical and super-canonical momentum currents between Euclidian and Minkowskian regions crucial for understand gravitational interaction as momentum exchange at imbedding space level.

5. What could be the physical interpretation of the bosonic and fermionic charges associated with objects of given dimension? Condensed matter physicists assign routinely physical states to objects of various dimensions: is this assignment much more than a practical approximation or could condensed matter physics already be probing many-sheeted physics?

3.7.2 SUSY and TGD

From this one ends up to the possibility of identifying the counterpart of SUSY in TGD framework [K16, ?].

1. In TGD the generalization of much larger super-conformal symmetry emerges from the super-symplectic symmetries of WCW. The mathematically questionable notion of super-space is not needed: only the realization of super-algebra in terms of WCW gamma matrices defining super-symplectic generators is necessary to construct quantum states. As a matter of fact, also in QFT approach one could use only the Clifford algebra structure for super-multiplets. No Majorana condition on fermions is needed as for $\mathcal{N} = 1$ space-time SUSY and one avoids problems with fermion number non-conservation.

2. In TGD the construction of sparticles means quite concretely adding fermions to the state. In QFT it corresponds to transformation of states of integer and half-odd integer spin to each other. This difference comes from the fact that in TGD particles are replaced with point like particles.

3. The analog of $\mathcal{N} = 2$ space-time SUSY could be generated by covariantly constant right handed neutrino and antineutrino. Quite generally the mixing of fermionic chiralities implied

by the mixing of M^4 and CP_2 gamma matrices implies SUSY breaking at the level of particle masses (particles are massless in 8-D sense). This breaking is purely geometrical unlike the analog of Higgs mechanism proposed in standard SUSY.

There are several options to consider.

1. The analog of brane hierarchy is realized also in TGD. Geometric action has parts assignable to 4-surface, 3-D light like regions between Minkowskian and Euclidian regions, 2-D string world sheets, and their 1-D boundaries. They are fixed uniquely. Also their fermionic counterparts - analogs of Dirac action - are fixed by super-conformal symmetry. Elementary particles reduce so composites consisting of point-like fermions at boundaries of wormhole throats of a pair of wormhole contacts.

   This forces to consider 3 kinds of SUSYs! The SUSYs associated with string world sheets and space-time interiors would certainly be broken since there is a mixing between M^4 chiralities in the modified Dirac action. The mass scale of the broken SUSY would correspond to the length scale of these geometric objects and one might argue that the decoupling between the degrees of freedom considered occurs at high energies and explains why no evidence for SUSY has been observed at LHC. Also the fact that the addition of massive fermions at these dimensions can be interpreted differently. 3-D light-like 3-surfaces could be however an exception.

2. For 3-D light-like surfaces the modified Dirac action associated with the Chern-Simons term does not mix M^4 chiralities (signature of massivation) at all since modified gamma matrices have only CP_2 part in this case. All fermions can have well-defined chirality. Even more: the modified gamma matrices have no M^4 part in this case so that these modes carry no four-momentum - only electroweak quantum numbers and spin. Obviously, the excitation of these fermionic modes would be an ideal manner to create spartners of ordinary particles consting of fermion at the fermion lines. SUSY would be present if the spin of these excitations couples - to various interactions and would be exact.

   What would be these excitations? Chern-Simons action and its fermionic counterpart are non-vanishing only if the CP_2 projection is 3-D so that one can use CP_2 coordinates. This strongly suggests that the modified Dirac equation demands that the spinor modes are covariantly constant and correspond to covariantly constant right-handed neutrino providing only spin.

   If the spin of the right-handed neutrino adds to the spin of the particle and the net spin couples to dynamics, $\mathcal{N}=2$ SUSY is in question. One would have just action with unbroken SUSY at QFT limit? But why also right-handed neutrino spin would couple to dynamics if only CP_2 gamma matrices appear in Chern-Simons-Dirac action? It would seem that it is independent degree of freedom having no electroweak and color nor even gravitational couplings by its covariant constancy. I have ended up with just the same SUSY-or-no-SUSY that I have had earlier.

3. Can the geometric action for light-like 3-surfaces contain Chern-Simons term?

   (a) Since the volume term vanishes identically in this case, one could indeed argue that also the counterpart of Kähler action is excluded. Moreover, for so called massless extremals of Kähler action reduces to Chern-Simons terms in Minkowskian regions and this could happen quite generally: TGD with only Kähler action would be almost topological QFT as I have proposed. Volume term however changes the situation via the cosmological constant. Kähler-Dirac action in the interior does not reduce to its Chern-Simons analog at light-like 3-surface.

   (b) The problem is that the Chern-Simons term at the two sides of the light-like 3-surface differs by factor $\sqrt{-1}$ coming from the ratio of $\sqrt{g_4}$ factors which themselves approach to zero: oOne would have the analog of dipole layer. This strongly suggests that one should not include Chern-Simons term at all.

   Suppose however that Chern-Simons terms are present at the two sides and α_K is real so that nothing goes through the horizon forming the analog of dipole layer. Both bosonic and fermionic degrees of freedom for Euclidian and Minkowskian regions would decouple completely but currents would flow to the analog of dipole layer. This is not physically attractive.

The canonical momentum current and its super counterpart would give fermionic source term $\Gamma^n \Psi_{int,\pm}$ in the modified Dirac equation defined by Chern-Simons term at given side $\pm$: $\pm$ refers to Minkowskian/Euclidian part of the interior. The source term is proportional to $\Gamma^n \Psi_{int,\pm}$ and Γ^n is in principle mixture of M^4 and CP_2 gamma matrices and therefore induces mixing of M^4 chiralities and therefore also 3-D SUSY breaking. It must be however emphasized that Γ^n is singular and one must be consider the limit carefully also in the case that one has only continuity conditions. The limit is not completely understood.

(c) If α_K is complex there is coupling between the two regions and the simplest assumption has been that there is no Chern-Simons term as action and one has just continuity conditions for canonical momentum current and hits super counterpart.

The cautious conclusion is that 3-D Chern-Simons term and its fermionic counterpart are absent.

4. What about the addition of fermions at string world sheets and interior of space-time surface ($D = 2$ and $D = 4$). For instance, in the case of hadrons $D = 2$ excitations could correspond to addition of quark in the interior of hadronic string implying additional states besides the states obtained assuming only quarks at string ends. Let us consider the interior ($D = 4$). For instance, inn the case of hadrons $D = 2$ excitations could correspond to addition of quark in the interior of hadronic string implying additional states besides the states obtained assuming only quarks at string ends. The smallness of cosmological constant implies that the contribution to the four-momentum from interior should be rather small so that an interpretation in terms of broken SUSY might make sense. There would be mass $m \sim .03$ eV per volume with size defined by the Compton scale $\hbar/m$. Note however that cosmological constant has spectrum coming as inverse powers of prime so that also higher mass scales are possible.

   This interpretation might allow to understand the failure to find SUSY at LHC. Sparticles could be obtained by adding interior right-handed neutrinos and antineutrinos to the particle state. They could be also associated with the magnetic body of the particle. Since they do not have color and weak interactions, SUSY is not badly broken. If the mass difference between particle and sparticle is of order $m = .03$ eV characterizing dark energy density ρ_{vac}, particle and sparticle could not be distinguished in higher energy physics at LHC since it probes much shorter scales and sees only the particle. I have already earlier proposed a variant of this mechanism but without SUSY breaking.

   To discover SUSY one should do very low energy physics in the energy range $m \sim .03$ eV having same order of magnitude as thermal energy $kT = 2.6 \times 10^{-2}$ eV at room temperature 25 °C. One should be able to demonstrate experimentally the existence of sparticle with mass differing by about $m \sim .03$ eV from the mass of the particle (one cannot exclude higher mass scales since Λ is expected to have spectrum). An interesting question is whether the sfermions associated with standard fermions could give rise to Bose-Einstein condensates whose existence in the length scale of large neutron is strongly suggested by TGD view about living matter.

3.8 Conclusions

The conclusion that the standard SUSY ($\mathcal{N} = 1$ SUSY with Majorana spinors) is absent in TGD Universe and also in the real one looks rather feasible in light of various arguments discussed in this chapter and also conforms with the LHC data. A more general SUSY with baryon and lepton conservation and Dirac spinors is however possible in TGD framework.

During the attempts to understand SUSY several ideas have emerged and the original discussions are retained as such in this chapter. It is interesting to see that their fate is if standard SUSY has no TGD counterpart.

1. One of the craziest ideas was that spartners indeed exists and even with the same p-adic mass scale but might be realized as dark matter. Same mass scale is indeed a natural prediction if right-handed neutrino and particle have same mass scale. Therefore even the mesons of ordinary hadron physics would be accompanied by smesons - pairs of squark and anti-squark. In fact, this is what the most recent form of the theory predicts: unfortunately there is no manner to experimentally distinguish between fermion and pseudo-sfermion if ν_R is zero momentum state lacking even gravitational interactions.

2. There are indications that charmonium as exotic states christened as X and Y mesons and the question was that they could correspond to mesons built either from colored excitations of charged quark and antiquark or from squark and anti-squark. The recent view leaves only the option based on colored excitations alive. The states in question would be analogous to pairs of color excitations of leptons introduced to explain various anomalies in leptonic sector [K13]. The question was whether lepto-hadrons could correspond to bound states of colored sleptons and have same p-adic mass scale as leptons have [K13]. The original form of lepto-hadron hypothesis remains intact.

3. Evidence that pion and also other hadrons have what could be called infrared Regge trajectories has been reported, and one could ask whether these trajectories could include spion identified as a bound state of squarks. Also this identification is excluded and the proposed identification in terms of stringy states assignable to long color magnetic flux tubes accompanying hadron remains under consideration. IR Regge trajectories would serve as a signature for the non-perturbative aspects of hadron physics.

4. The latest idea along these lines is that spartners are obtained by adding right-handed neutrinos to the interior of space-time surface assignable to the particle. SUSY would not be detectable at high energies, which would explain the negative findings at LHC. Spartners could be discovered at low energy physics perhaps assignable to the magnetic bodies of particles: the mass scale could be as low .03 eV determined by cosmological constant in the scale of cosmology. Note however that cosmological constant has spectrum coming as inverse powers of prime.

4 Experimental Situation

The experimental situation in the case of SUSY is still open but it there are excellent hopes that the results from LHC will determine the fate of the MSSM SUSY and also constraint more general scenarios. Unfortunately, the research concentrates to the signatures of MSSM and its variants quite different from those of TGD SUSY so that it might happen that TGD SUSY will be discovered accidentally if its there: say by the decays of spartner to partner and neutrino. Already from the recent results it is clear that the allowed parameter space for MSSM SUSY is very small and that superpartners of quarks and also weak gauge bosons must be very heavy if MSSM SUSY is realized. This leads to difficulties with the only known evidence for SUSY coming from the g-2 anomaly of muon. TGD based SUSY allows light masses and also SUSY explanation of g-2 anomaly if sneutrino masses are light.

The representation involves a lot of references to blog postings and this might irritate so called serious scientists. I however feel that since blogs provide my only contact to the particle physics it is only fair to make clear that this communication tool is absolutely essential for a scientist working as out-of-law in academic community. Blogs could indeed bring democracy to science and mean end of the era of secrecy and censorship by the referee system.

4.1 Almost Predictions Related To SUSY

4.1.1 Electroweak symmetry breaking

The recent view about electroweak symmetry breaking is less than year old. The basic realization was that wormhole throats carrying elementary particle quantum numbers possess Kähler magnetic charge (in homological sense- CP_2 has non-trivial second homology). This magnetic charge must be compensated and this is achieved if the particle wormhole throat is connected to a second wormhole throat by a magnetic flux tube. The second wormhole would carry a weak charge of neutrino pair compensating the weak isospin of the particle so that weak interactions would be screened above the weak length scale. For colored states the compensation could also occur in longer length scale and corresponds to color confinement.

This does not actually require the length scale of flux tubes associated with all elementary particles to be the weak length scale as I have thought. Rather, the flux tube length for a particle at rest could correspond to the Compton length of the particle. For instance, for electron the maximal flux tube length would be about 10^{-13} meters. For particles not at rest the length would get shorter by length contraction. For very light but massive particles such as photon and graviton the maximum length of flux tube would be very long. The interaction of very low energy photons and gravitons would be essentially classical and induced by the classical oscillations of induced gauge fields induced by a long flux tube connecting the interacting systems. For high energy quanta this interaction would be essentially quantal and realized as absorption of quanta with flux tube length -essentially wave length of quantum- much shorter than the distance between the interacting systems. Gravitational waves would interact essentially classically even when absorbed since absorption would mean that the flux tube would connects two parts of the measurement apparatus. For large $\hbar$ gravitons the length of flux tube could correspond to the distance between interaction systems.

A fascinating possibility is that electronic Cooper pairs of superconductors with large value of $\hbar$, could correspond to long flux tubes with electron's quantum numbers at both ends. Maybe this takes place in high T_c super conductors.

4.1.2 Some details of the SUSY predictions

TGD SUSY differs from the standard SUSY in many respects.

1. All fermionic oscillator operators assignable to the wormhole throats generate supersymmetries. These oscillator operators differ from ordinary ones in that they do not have momentum label and momentum can be only assigned to the entire state. Therefore the interpretation of all states assignable to wormhole throats as large SUSY multiplet is possible. This SUSY is badly broken and there is hierarchy of breakings defined by the interactions inducing the breaking in turn define by the quantum numbers of SUSY generators. For quark generators the breaking is largest and the smallest breaking is associated with the oscillator operators assignable to right-handed neutrinos since they have only gravitational interactions.

2. The symmetry generators are not Majorana spinors and this does not lead to any difficulties as has been found. Only if one would try stringy quantization trying to define stringy diagrams in terms of stringy propagators defined by stringy form of super-conformal algebra, one would end up with difficulties. Majorana property is also excluded by the separate conservation of baryon and lepton number.

   For single wormhole throat one can see the situation in terms of N=2 SUSY with right handed neutrino and its antiparticle appearing as SUSY generators carrying conserved fermion number. One can classify the superpartners by their right-handed neutrino number which is +/-1. For instance, for single wormhole throat one obtains fermion and its partner containing ν_R pair, and fermion number 0 and fermion number 2 sfermions. In the case of gauge bosons and Higgs similar degeneracy is obtained for both wormhole throats.

3. Since induced gamma matrices and Kähler-Dirac gamma matrices are mixtures of M^4 and CP_2 gamma matrices right handed neutrino is mixed with the left handed neutrino meaning breaking of R-parity. The simplest decays of sparticles are of form $P \rightarrow P+\nu$ and can be said to be gravitationally induced since the mixing of gamma matrices is indeed a characteristic phenomenon of induced spinor structure. Also more complex decays with neutrino replaced with charge lepton are possible. The basic signature is lonely lepton not possible in decays of weak bosons.

4. The basic outcome of SUSY QFT limit of TGD [K5] is that wormhole throat can carry only spin 0, 1/2, 1 corresponding to fermion and fermion pair if one wants to obtain standard propagator: otherwise one obtains $1/p^n$, $n > 2$ and this is not an ordinary particle pole. The

reason is that one cannot assign to fermionic oscillator operators independent momenta but only common momentum so they propagate effectively collinearly.

One can criticize this argument as being inconsistent with the twistorial approach combined with zero energy ontology implying that wormhole throats are massless even for on mass shell states. In this approach one in principle avoids completely the use of propagators which would of course diverge for on shell wormhole throats. Also for twistor diagrams the counterparts of virtual particles are massless and off shell. The so called region momentum replaces momentum in Grassmannian twistor approach and has a direct counterpart as eigenvalue of the Kähler-Dirac operator so that the analog of propagator exists in TGD framework. Since QFT limit must be a reasonable approximation to the full theory, one might hope that the QFT based argument makes sense when one replaces momentum with region momentum (or pseudo momentum as I have called it in TGD framework).

5. Should one allow both $\nu_R$and its antiparticle as SUSY generators? This would mean more states as in standard SUSY for which only $\overline{\nu}_R$ would be allowed for fermion. This would assign to a given wormhole throat with fermion number 1 spin 1 and spin 0 super partner and companion of fermion containing $\nu_R - \overline{\nu}_R$ pair. For this state however propagator would behave like $1/p^3$ should that again strong SUSY breaking would occur for this extended SUSY. Only one half of SUSY would be broken weakly by the mixing of M^4 and CP_2 gamma matrices appearing in Kähler-Dirac gamma matrices: the mixing would not involve weak or color interactions but could be said to be gravitational but not in the sense of abstract for geometry but induced geometry.

   The breaking of symmetries by this mechanism would be a beautiful demonstration that it is sub-manifold geometry rather than abstract manifold geometry that matters. Again string theorists managed to miss the point by effectively eliminating induced geometry from the original string model by inducing the metric of space-time sheet as an independent variable. The motivation was that it became easy to calculate! The price paid was symmetry breaking mechanisms involving hundreds of three parameters.

6. Single wormhole contact could carry spin J=2 and give rise to graviton like state. If one constructs from this gravitino by adding right-handed neutrinos, and if SUSY QFT limit makes sense, one obtains particle with propagator decreasing faster at either throat so that gravitino in standard sense would not exist. This would represent strong SUSY breaking in gravitational sector. These results are of utmost importance since the basic argument in favor dimension D=10 or D=11 for the target space of superstring models is that higher dimensions would give fundamental massless particles with higher spin.

   Note that the replacement of wormhole throats by flux tubes having neutrino pair at the second end of the flux tube complicates the situation since one can add right handed neutrino also to the neutrino end. The SUSY QFT criterion would however suggest that these states are not particle like.

4.1.3 Super-symplectic bosons

TGD predicts also exotic bosons which are analogous to fermion in the sense that they correspond to single wormhole throat associated with CP_2 type vacuum extremal whereas ordinary gauge bosons corresponds to a pair of wormhole contacts assignable to wormhole contact connecting positive and negative energy space-time sheets. These bosons have super-conformal partners with quantum numbers of right handed neutrino and thus having no electro-weak couplings. The bosons are created by the purely bosonic part of super-symplectic algebra [K3, K15], whose generators belong to the representations of the color group and 3-D rotation group but have vanishing electro-weak quantum numbers. Their spin is analogous to orbital angular momentum whereas the spin of ordinary gauge bosons reduces to fermionic spin. Recall that super-symplectic algebra is crucial for the construction of WCW Kähler geometry. If one assumes that super-symplectic gluons suffer topological mixing identical with that suffered by say U type quarks, the conformal weights would be (5, 6, 58) for the three lowest generations. The application of super-symplectic bosons in TGD based model of hadron masses is discussed in [K10] and here only a brief summary is given.

As explained in [K10], the assignment of these bosons to hadronic space-time sheet is an attractive idea.

1. Quarks explain only a small fraction of the baryon mass and that there is an additional contribution which in a good approximation does not depend on baryon. This contribution should correspond to the non-perturbative aspects of QCD. A possible identification of this contribution is in terms of super-symplectic gluons. Baryonic space-time sheet with $k = 107$ would contain a many-particle state of super-symplectic gluons with net conformal weight of 16 units. This leads to a model of baryons masses in which masses are predicted with an accuracy better than 1 per cent.

2. Hadronic string model provides a phenomenological description of non-perturbative aspects of QCD and a connection with the hadronic string model indeed emerges. Hadronic string tension is predicted correctly from the additivity of mass squared for $J = 2$ bound states of super-symplectic quanta. If the topological mixing for super-symplectic bosons is equal to that for U type quarks then a 3-particle state formed by 2 super-symplectic quanta from the first generation and 1 quantum from the second generation would define baryonic ground state with 16 units of conformal weight. A very precise prediction for hadron masses results by assuming that the spin of hadron correlates with its super-symplectic particle content.

3. Also the baryonic spin puzzle caused by the fact that quarks give only a small contribution to the spin of baryons, could find a natural solution since these bosons could give to the spin of baryon an angular momentum like contribution having nothing to do with the angular momentum of quarks.

4. Super-symplectic bosons suggest a solution to several other anomalies related to hadron physics. The events observed for a couple of years ago in RHIC [C18] suggest a creation of a black-hole like state in the collision of heavy nuclei and inspire the notion of color glass condensate of gluons, whose natural identification in TGD framework would be in terms of a fusion of hadronic space-time sheets containing super-symplectic matter materialized also from the collision energy. In the collision, valence quarks connected together by color bonds to form separate units would evaporate from their hadronic space-time sheets in the collision, and would define TGD counterpart of Pomeron, which experienced a reincarnation for few years ago [C20]. The strange features of the events related to the collisions of high energy cosmic rays with hadrons of atmosphere (the particles in question are hadron like but the penetration length is anomalously long and the rate for the production of hadrons increases as one approaches surface of Earth) could be also understood in terms of the same general mechanism.

4.2 Goodbye Large Extra Dimensions And MSSM

New results giving strong constraints on large extra dimensions and on the parameters of minimally supersymmetric standard model (MSSM) have come from LHC and one might say that both larger extra dimensions and MSSM are experimentally excluded.

4.2.1 The problems of MSSM

According to the article The fine-tuning price of the early LHC by A. Strumia [C7] the results from LHC reduce the parameter space of MSSM dramatically. Recall that the king idea of MSSM is that the presence of super partners tends to cancel the loop corrections from ordinary particles giving to Higgs mass much larger correction that the mass itself. Note that the essential assumption is that R-parity is an exact symmetry so that the lightest superpartner is stable. The signature of SUSY is indeed missing energy resulting in the decay chain beginning with the decay of gluino to chargino and quark pair followed by the decay of chargino to W boson and neutralino representing missing energy.

The article Search for supersymmetry using final states with onelepton, jets, and missing transverse momentum with the ATLAS detector in $s^{1/2} = 7$ TeV pp collisions [C5] by ATLAS collaboration at LHC poses strong limits on the parameters of MSSM implying that the mass of gluino is above 700 GeV in the case that gluino mass is same as that of squark. In Europhysics 1011 meeting the lower bounds for squark and gluino masses were raised to about 1 TeV. The experimental lower bounds on masses of superpartners are so high and the upper bound on Higgs mass so low that the superpartners cannot give rise to large enough compensating corrections to stabilize Higgs. This requires fine-tuning even in MSSM known as little hierarchy problem.

In typical models this also means that the bounds on slepton masses are too high to be able to explain the muonic g-2 anomaly, which was one of the original experimental motivations for MSSM. Therefore the simplest candidates for supersymmetric unifications are lost. This strengthens the suspicion that something is badly wrong with the standard view about SUSY forcing among other things to assume instability of proton due to non-conservation of baryon and lepton numbers separately.

4.2.2 The difficulties of large extra dimensions

The results from LHC do not leave much about the dream of solving hierarchy problem using SUSY. One must try something else. One example of this something else are large extra dimensions implying massive graviton, which could provide a new mechanism for massivation based on the idea that massive particle in Minkowski space are massless particles in higher dimensional space (also essential element of TGD). This could perhaps the little hierarchy problem if the mass of Kaluza-Klein graviton is in TeV range.

The article LHC bounds on large extra dimensions by A. Strumia and collaborators [C3] poses very strong constraints on large extra dimensions and mass and effective coupling constant parameter of massive graviton. Kaluza-Klein graviton would appear in exchange diagrams and loop diagrams for 2-jet production and could become visible in higher energy proton-proton collisions at LHC. KK graviton would be also produced as invisible KK-graviton energy in proton-proton collisions. The general conclusion from data gathered hitherto shrinks dramatically the allowed parameter space for the KK-graviton. Does this mean that we are left with the anthrophic option?

4.2.3 Also M-theorists admit that there are reasons for the skepticism

Michael Dine admits in the article Supersymmetry From the Top Down [C6] that there are strong reasons for skepticism. Dine emphasizes that the hierarchy problem related to the in-stability of Higgs mass due to the radiative corrections is the main experimental motivation for SUSY but that little hierarchy problem remains the greatest challenge of the approach. As noticed, in TGD this problem is absent. The same basic vision based on zero energy ontology and twistors predicts among other things

- the cancellation of UV and IR infinities in generalized Feynman (or more like twistor-) diagrammatics,
- predicts that in the electroweak scale the stringy character of particles identifiable as magnetically charged wormhole flux tubes should begin to make itself manifest,
- particles regarded usually as massless eat all Higgs like particles accompanying them (here "predict" is perhaps too strong a statement),
- also pseudo-scalar counterparts of Higgs-like particles which avoid the fate of their scalar variants (there already exist indications for pseudo-scalar gluons).

Combined with the powerful predictions of p-adic thermodynamics for particle masses these qualitative successes make TGD a respectable candidate for the follower of string theory.

4.2.4 Could TGD approach save super-symmetry?

In TGD framework the situation is not at all so desolate. Due to the differences between the induced spinor structure and ordinary spinors, Higgs corresponds to SU(2) triplet and singlet in TGD framework rather than complex doublet. The recent view about particles as bound states of massless wormhole throats forced by twistorial considerations and emergence of physical particles as bound states of wormhole contacts carrying fermion number and vibrational degrees of freedom strongly suggests- I do not quite dare to say "implies" - that also photon and gluons become massive and eat their Higgs partners to get longitudinal polarization they need. No Higgs- no fine tuning of Higgs mass- no hierarchy problems.

Note that super-symmetry is not given up in TGD but differs in many essential respects from that of MSSM. In particular, super-symmetry breaking and breaking of R-parity are automatically present from the beginning and relate very closely to the massivation.

1. If the gamma matrices were induced gamma matrices, the mixing would be large by the light-likeness of wormhole throats carrying the quantum numbers. Induced gamma matrices are however excluded by internal consistency requiring Kähler-Dirac gamma matrices obtained as contractions of canonical momentum densities with imbedding space gamma matrices. Induced gamma matrices would require the replacement of Kähler action with 4-volume and this is unphysical option.

2. In the interior Kähler action defines the canonical momentum densities and near wormhole throats the mixing is large: one should note that the condition that the Kähler-Dirac gamma matrices multiplied by square root of metric determinant must be finite. One should show that the weak form of electric-magnetic duality guarantees this: it could even imply the vanishing of the limiting values of these quantities with the interpretation that the space-time surfaces becomes the analog of Abelian instanton with Minkowski signature having vanishing energy momentum tensor near the wormhole throats. If this is the case, Euclidian and Minkowskian regions of space-time surface could provide dual descriptions of physics in terms of generalized Feynman diagrams and fields.

3. At wormhole throats Abelian Chern-Simons-Kähler action with the constraint term guaranteeing the weak form of electric-magnetic duality defines the Kähler-Dirac gamma matrices. Without the constraint term Chern-Simons gammas would involve only CP_2 gamma matrices and no mixing of M^4 chiralities would occur. The constraint term transforming TGD from topological QFT to almost topological QFT by bringing in M^4 part to the Kähler-Dirac gamma matrices however induces a mixing proportional to Lagrange multiplier. It is difficult to say anything precise about the strength of the constraint force density but one expect that the mixing is large since it is also large in the nearby interior.

If the mixing of the Kähler-Dirac gamma matrices is indeed large, the transformation of the right-handed neutrino to its left handed companion should take place rapidly. If this is the case, the decay signatures of spartners are dramatically changed as will be found and the bounds on the masses of squarks and gluinos derived for MSSM do not apply in TGD framework.

1. Proposal for the mass spectrum of sfermions

In TGD framework p-adic length scale hypothesis (stating that preferred p-adic primes come as $p \simeq 2^k$, k integer) allows to predict the masses of sleptons and squarks modulo scaling by a powers $\sqrt{2}$ determined by the p-adic length scale by using information coming from CKM mixing induced by topological mixing of particle families in TGD framework. Also natural guesses for the mass scales of ew gauginos and gluinos are obtained.

1. If one assumes that the mass scale of SUSY corresponds to Mersenne prime M_{89} assigned with intermediate gauge bosons one obtains unique predictions for the various masses apart from uncertainties due to the mixing of quarks and neutrinos [K6].

2. In first order the p-adic mass formulas for fermions read as

$$\begin{aligned} m_F &= \sqrt{\frac{n_F}{5}} \times 2^{(127-k_F)/2} \times m_e \ , \\ n_L &= (5,14,65) \ , \ n_\nu = (4,24,64) \ , \ n_U = (5,6,58) \ , \ n_D = (4,6,59) \ . \end{aligned} \tag{4.1}$$

   Here k_F is the integer characterizing p-adic mass scale of fermion via $p \simeq 2^{k_F}$. The values of k_F are not listed here since they are not needed now. Note that electroweak symmetry breaking distinguish U and D type fermions is very small when one uses p-adic length scale as unit.

By taking $k_F = 89$ for super-partners as a reference mass scale, one obtains in good approximation (the first calculation contained erratic scaling factor)

$$\begin{aligned} \frac{m_{\tilde{L}}}{GeV} &= 2^{(89-k_F)/2}(262, 439, 945) \quad , \\ \frac{m_{\tilde{\nu}}}{GeV} &= 2^{(89-k_F)/2}(235, 423, 938) \quad , \\ \frac{m_{\tilde{U}}}{GeV} &= 2^{(89-k_F)/2}(262, 287, 893) \quad , \\ \frac{m_{\tilde{D}}}{GeV} &= 2^{(89-k_F)/2}(235, 287, 900) \quad . \end{aligned} \tag{4.2}$$

Charged leptons correspond to subsequent Mersennes or Gaussian Mersennes. The first guess is that this holds true also for charged sleptons. This would give $k_F(\tilde{e}) = 89$, $k_F(\tilde{\mu}) = 79$, and $k_F(\tilde{\tau}) = 61$. For quarks one has $k_F(q) \geq 113$ ($k = 113$ corresponds to Gaussian Mersenne). If one generalizes this to $k_F(\tilde{q}) \leq 79$, all sfermion masses expect those of selectron and sneutrinos are above 13 TeV. This option might well be consistent with the recent experimental data require that squark masses are above 1 TeV. The possible problem is selectron mass 262 GeV.

3. The simplest possibility is that ew gauginos are characterized by $k = 89$ and have same masses as W and Z in good approximation. Therefore $\tilde{W}$ could be the lightest super-symmetric particle and could be observed directly if the neutrino mixing is not too fast and allowing the decay $\tilde{W}+\nu$. Also gluinos could be characterized by M_{89} and have mass of order intermediate gauge boson mass. For this option to be discussed below the decay scenario of MSSM changes considerably.

4. It should be noticed that the single strange event reported 1995 [C26] discussed in [?]ives for the mass of selectron the estimate 131 GeV, which corresponds to M_{91} instead of M_{89} and is thus one half of the selectron mass for Mersenne option. This event allowed also to estimate the masses of Zino and corresponding Higgsino. The results are summarized by the following table:

$$m(\tilde{e}) = 131 \;\; GeV \quad , \quad m(\tilde{Z}^0) = 91.2 \;\; GeV \quad , \quad m(\tilde{h}) = 45.6 \;\; GeV \quad . \tag{4.3}$$

If one takes these results at face value one must conclude either that M_{89} hypothesis is too strong or M_{SUSY} corresponds to M_{91} or that M_{89} is correct identification but also sfermions can appear in several p-adic mass scales.

The decay cascades searched for in LHC are initiated by the decay $q \rightarrow \tilde{q} + \tilde{g}$ and $g \rightarrow \tilde{q} + \tilde{q}_c$. Consider first R-parity conserving decays. Gluino could decay in R-parity conserving manner via $\tilde{g} \rightarrow \tilde{q} + q$. Squark in turn could decay via $\tilde{q} \rightarrow q_1 + \tilde{W}$ or via $\tilde{q} \rightarrow q + \tilde{Z}^0$. For the proposed first guess about masses the decay $\tilde{W} \rightarrow \nu_e + \tilde{e}$ or $\tilde{Z}^0 \rightarrow \nu_e + \tilde{\nu}_e$ would not be possible on mass shell.

If the mixing of right-handed and left-handed neutrinos is fast enough, R-parity is not conserved and the decays $\tilde{g} \rightarrow g + \nu$ and $\tilde{q} \rightarrow q + \nu$ could take place by the mixing $\nu_R \rightarrow \nu_L$ following by electroweak interaction between ν_L quark or antiquark appearing as composite of gluon. The decay signature in this case would be pair of jets (quark and antiquark or gluon gluon jet both containing a lonely neutrino not accompanied by a charged lepton required by electroweak decays. Also the decays of electroweak gauginos and sleptons could produce similar lonely neutrinos.

The lower bound to quark masses from LHC is about 600 GeV and 800 GeV for gluon masses assuming light neutralino is slightly above the proposed masses of lightest squarks [C17]. In Europhysics 2011 lower bounds were raised to 1 TeV for both gluino and squark masses. These bounds are consistent with the above speculative picture. These masses are allowed for R-parity conserving option if the decay rate producing chargino is reduced by the large mass of chargino the bounds become weaker. If the decay via R-parity breaking is fast enough no bounds on masses of squarks and gluinos are obtained in TGD framework but jets with neutrino unbalanced by a charged lepton should be observed.

2. How to relate MSSM picture to TGD picture?

In order to utilize MSSM calculation in TGD framework one must relate MSSM picture to TGD picture. The basic constraint is that Higgs is absent. This could apply also to Higgsino. This certainly simplifies the formulas. A further condition is that superpartners obey the same mass formulas as partners for same pa-dic length scale.

It has been proposed that the loops involving superpartners could explain the anomaly [C15]. In one-loop order one would have the processes $\mu \rightarrow \tilde{\mu} + \tilde{Z}^0$ and $\mu \rightarrow \tilde{\nu}_\mu + \tilde{W}^0$. The situation is complicated by the possible mixing of the gauginos and Higgsinos and in MSSM this mixing is described by the mixing matrices called X and Y. The general conclusion is however clear: if muonic sneutrino is light, it is possible to have sizeable contribution to the g-2 anomaly.

1. Magnetic moment operator mixes different M^4 chiralities. For simplest one-loop diagrams this corresponds in TGD framework to coupling in the Kähler-Dirac equation mixing different chiralities describable as an effective mass term. The couplings between right and left handed sfermions also contributes to the magnetic moment and these couplings reduce to those of sfermions being basically induced by the fermionic chirality mixing which reduces to the fact that Kähler-Dirac gamma matrices are superpositions of M^4 and CP_2 gamma matrices.

2. The basic outcome in the standard SUSY approach is that the mixing is proportional to the factor m_μ^2/m_{SUSY}^2. One expects that in the recent situation $m_{SUSY} = m_W$ is a reasonable first guess so that the mixing is large and could explain the anomaly. Second guess is as M_{89} p-adic mass scale.

3. MSSM calculations for anomalous g-2 involve the mixing of both $\tilde{f}_L$ and $\tilde{f}_R$ and of gauginos and Higgsinos. In MSSM the mixing matrices involve the parameter $tan(\beta)$ where the angle β characterizes the ratio of mass scales of U and D type fermions fixed by the ratio of Higgs expectations for the two complex Higgs doublets [C15]. $tan(\beta)$ also characterizes in MSSM the ratio of vacuum expectation values of two Higgses assignable to U and D type quarks and cannot be fixed from this criterion since in TGD framework one has one scalar Higgs and pseudo-scalar Higgs decomposing to triplet and singlet under SU(2) and the mass ratio is fixed by p-adic mass calculations.

The question is what happens if Higgs and Higgsino are absent and what one can conclude about the value of β in TGD framework where p-adic mass calculations give the dominant contribution to fermion masses and the mass formulas for particles and sparticles should be identical for a fixed p-adic prime.

2.1 Mixing of charged gauginos and Higgsinos

Consider first the mixing between charged gauginos and Higgsinos. The angle β characterizes also the mixing of $\tilde{W}$ and charged Higgsino parametrized by the mass matrix

$$X = \begin{pmatrix} M_2 & M_W\sqrt{2}sin(\beta) \\ M_W\sqrt{2}cos(\beta) & \mu \end{pmatrix} . \tag{4.4}$$

The $tan(\beta)$ gives the ratio of mass scales of U and D type quarks in MSSM. In MSSM $tan(\beta)$ reduces to the ratio of Higgs vacuum expectations and it would be better to get rid of the entire parameter in TGD framework. The maximally symmetric situation corresponds to the same mass scale for U and D type quarks and this suggests that one has $sin(\beta) = cos(\beta) = 1/\sqrt{2}$ implying $tan(\beta) = 1$. In MSSM $tan(\beta) > 2$ is required and this is due to the large value of the m_{SUSY}.

Whether this parameterization makes sense in TGD framework depends on whether one allows Higgsino.

1. If also Higgsino is absent the formula does not make sense. A natural condition is that the value of $tan(\beta)$ does not appear at all in the limiting formulas for the anomalous g-2. Note that in p-adic mass calculations do not contain this kind of a priori continuous parameter. There the simplest TGD based option is that the Higgsino is just absent and the mass matrix reduces 1×1 matrix M_2 giving wino mass. The idea that particle and sparticles have identical masses for the same p-adic mass scale would give $M_2 = M_W$. One must however remember that in TGD framework mass operator acts like a preferred combination of gamma matrices in CP_2 degrees of freedom mixing M^3 chiralities.

2. If one allows Higgsinos, the simplest guess is that apart from p-adic mass scale same has $M_2 = -\mu = m$: this guarantees identical masses for the mixed states in accordance with the ideas that different masses for particles and sparticles result from the different p-adic length scale. For $cos(\beta) = 1/\sqrt{2}$ this would give mass matrix with eigen values $(M, -M)$, $M = \sqrt{m^2 + m_W^2}$ so that mass squared values of of the mixed states would be identical and above m_W mass for $p = M_{89}$. Symmetry breaking by an increase of the p-adic length scale could however reduce the mass of other state by a power of $\sqrt{2}$.

   If also winos and zinos eat the higgsinos, one can argue that the determinant of X must vanish so that the eigenstate with vanishing eigen value would correspond to an unphysical state meaning the elimination of second state from the spectrum. This would require $M_2\mu - M_W^2 sin(2\beta) = 0$. $sin(\beta) = 1/\sqrt{2}$ and $M_2 = \mu = M_W$ is the simplest solution to the condition. This looks tricky.

2.2 Mixing of neutral gauginos and Higgsinos

In MSSM 4×4 matrix is needed to describe the mixing of neutral gauginos and two kinds of neutral Higgsinos. In TGD framework second Higgs (if it exists at all) is pseudo-scalar and does not contribute and the 2×2 matrices describe the mixing also now.

$$X = \begin{pmatrix} \begin{pmatrix} M_1 & 0 \\ 0 & M_2 \end{pmatrix} & M_Z \begin{pmatrix} s_W cos(\beta) & s_W sin(\beta) \\ c_W cos(\beta) & c_W sin(\beta) \end{pmatrix} \\ M_Z \begin{pmatrix} s_W cos(\beta) & s_W sin(\beta) \\ c_W cos(\beta) & c_W sin(\beta) \end{pmatrix} & -\mu \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \end{pmatrix} . \tag{4.5}$$

For $sin(\beta) = cos(\beta) = 0$ the non-diagonal part of the mass matrix is degenerate.

Again there are two options depending on whether Higgsinos are present and if they are absent the dependence on the angle β vanishes. Indeed, if Higgsinos are absent the matrix reduces to a diagonal 2×2 mass matrix for U(1) gaugino $\tilde{B}$ and neutral SU(2) gaugino $\tilde{W}^3$. If one takes seriously MSSM, there would be no mixing. On the other hand, TGD suggests that neutral gauginos mix in the same manner as neutral gauge bosons so that Weinberg angle would characterize the mixing with photino and zino appearing as mass eigen states. Again for same value of p-adic prime the values of mass squared for gauge bosons and gauginos should be identical.

One can also consider the option with Higgsino.

1. Since Higgs and Higgsino have representation content 3+1 with respect to electroweak SU(2) in TGD framework, one can speak about $\tilde{h}_B$, $B = W, Z, \gamma$. An attractive assumption is that Weinberg angle characterizes also the mixing giving rise to $\tilde{Z}$ and $\tilde{\gamma}$ on one hand and $\tilde{h}_\gamma$ and $\tilde{h}_Z$ on the other hand if these belong to the spectrum. This would reduce the mixing matrix to two 2×2 matrices: the first one for $\tilde{\gamma}$ and $\tilde{h}_\gamma$ and the second one for $\tilde{Z}$ and $\tilde{h}_Z$.

2. A further attractive assumption is that the mass matrices describing mixing of gauginos and corresponding Higgsinos are in some sense universal with respect to electroweak interactions. The form of the mixing matrix would be essentially same for all cases. This would suggest that M_W is replaced in the above formula with the mass of Z^0 and photon in these matrices (recall that it is assumed that photon gets small mass by eating the neutral Higgs). Note that for photino and corresponding Higgsino the mixing would be small. The guess is $M_2 = -\mu = m_Z$. For photino one can guess that M_2 corresponds to M_{89} mass scale.

These assumptions of course define only the first maximally symmetric guess and the simplest modification that one can imagine is due to the different p-adic mass scales. If the above discussed values for zino and neutralino masses deduced from the 1995 event [C26] are taken at face value, the eigenvalues would be $\pm\sqrt{M_Z^2+m^2}$ with $m = M_2 = -\mu$ for $\tilde{Z} - \tilde{h}_Z$-mixing and the other state would have p-adic length scale $k = 91$ rather than $k = 89$. M and μ would have opposite signs as required by the correct sign for the $g-2$ anomaly for muon assuming that smuons correspond to $p = M_{89}$ as will be found.

2.3 The relationship between masses of charged sleptons and sneutrinos

In MSSM approach one has also the formula relating the masses of sneutrinos and charged sleptons [C15]:

$$m_{\tilde{\nu}}^2 = m_{\tilde{L}}^2 + \frac{1}{2}M_Z^2 cos(2\beta) \ . \tag{4.6}$$

For $\beta = \pm\pi/4$ one would have $tan(\beta) = 1$ and

$$m_{\tilde{\nu}}^2 = m_{\tilde{L}}^2 \ .$$

In p-adic mass calculations this kind of formula is highly questionable and could make sense only if the particles involved correspond to same value of p-adic prime and therefore would not make sense after symmetry breaking.

3. The anomalous magnetic moment of muon as a constraint on SUSY

The anomalous magnetic moment $a_\mu \equiv (g-2)/2$ of muon has been used as a further constraint on SUSY. The measured value of a_μ is $a_\mu^{exp} = 11659208.0(6.3) \times 10^{10}$. The theoretical prediction decomposes to a sum of reliably calculable contributions and hadronic contribution for which the low energy photon appearing as vertex correction decays to virtual hadrons. This contribution is not easy to calculate since non-perturbative regime of QCD is involved. The deviation between prediction and experimental value is $\Delta a_\mu(exp - SM) = 23.9(9.9) \times 10^{-10}$ giving $\Delta a_\mu(exp - SM/)a_\mu = 2 \times 10^{-6}$. The hadronic contribution is estimated to be 692.3×10^{-10} so that the anomaly is 3 per cent from the hadronic contribution [C15]. One can ask whether the uncertainties due to the non-perturbative effects could explain the anomaly.

The following calculation is a poor man's version of MSSM calculation [C15]. Also now SUSY requires that the electroweak couplings between particles dictate those between sparticles. Supersymmetry for massivation suggests that in TGD framework higgsinos do not belong to the spectrum. Light sfermions appear as single copy with vanishing fermion number so that various mixing matrices of MSSM reduce to unit matrices. This leads to a rough recipe: take only the one loop contributions to g-2 and assume trivial mixing matrices and drop off summations. At least a good order of magnitude estimate should result in this manner.

3.1 A rough MSSM inspired estimate g-2 anomaly

Consider now a rough estimate for the g-2 anomaly by using the formulas 56-58 of [C15]. One obtains for the charged loop the expression

$$\Delta a_\mu^{\pm} = -\frac{21 g_2^2}{32\pi^2} \times (\frac{m_\mu}{m_W})^2 \times sign(\mu M_2) \ . \tag{4.7}$$

This however involves a formula relating sneutrino and charged slepton masses. There is no reason to expect this formula to hold true in TGD framework.

For neutral contribution the expression is more difficult to deduce. As physical intuition suggests, the expression inversely proportional to $1/m_W^2$ since m_W corresponds now m_{SUSY} although this is not obvious on the basis of the general formulas suggesting the proportionality toi $1/m_{\tilde{\nu}_\mu}^2$. The p-adic mass scale corresponding to M_{89} is the natural guess for M_{SUSY} and would give $M_{SUSY} = 104.9$ GeV. The fact that the correction has positive sign requires that μ and M_2 have opposite signs unlike in MSSM. The sign factor is opposite to that in MSSM because sfermion mass scales are assumed to be much higher than weak gaugino mass scale.

The ratio of the correction to the lowest QED estimate $a_{\mu,0} = \alpha/2\pi$ can be written as

$$\frac{\Delta a_\mu^+}{a_{\mu,0}} = \frac{21}{4sin^2(\theta_W)} \times (\frac{m_\mu}{m_{SUSY}})^2 \simeq 2.73 \times 10^{-5} \quad . \tag{4.8}$$

which is roughly 10 times larger than the observed correction. The contribution Δa_μ^0 could reduce this contribution. At this moment I am however not yet able to transform the formula for it to TGD context. Also the scaling up of the m_{SUSY} by a factor of order $2^{3/2}$ could reduce the correction.

The parameter values $(tan(\beta) = 1, M_{SUSY} = 100 \text{ GeV})$ corresponds to the boundary of the region allowed by the LHC data and $g-2$ anomaly is marginally consistent with these parameter values (see figure 16 of [C15]). The reason is that in the recent case the mass of lightest Higgs particle does not pose any restrictions (the brown region in the figure). Due to the different mixing pattern of gauginos and higgsinos in neutral sector TGD prediction need not be identidal with MSSM prediction.

The contribution from Higgs loop is not present if Higgs is eaten by photon [C24]. This contribution by a factor of order $(m_\mu/h_H)^2$ smaller than the estimate for the SUSY contribution so that the dropping of Higgs contribution does not affect considerably the situation.

$$\Delta a_\mu^H = \frac{2}{2.24^2}((\frac{m_\mu}{m_H})^4) \times (log((\frac{m_H}{m_\tau})^2) - \frac{3}{2}) \quad . \tag{4.9}$$

The proposed estimate is certainly poor man's estimate since it is not clear how near the proposed twistorial approach relying on zero energy ontology is to QFT approach. It is however encouraging that the simplest possible scenario might work and that this is essentially due to the p-adic length scale hypothesis.

3.2 An improved estimate for g-2 anomaly

An attractive scenario for sfermion masses marginally consistent with the recent data from LHC generalizes the observation that charged lepton masses correspond to subsequent Mersenne primes of Gaussian Mersennes. The only sfermions lighter than about 13 TeV are selectron with mass 262 GeV ($k = 89$) and sneutrinos, which can have much smaller masses. $\tilde{W}\tilde{\nu}_\mu$ virtual state would be mostly responsible for the muonic g-2 anomaly since the largest term in the correction is proportional to $m(\mu)m(\tilde{W})/m^2(\tilde{\nu}_\mu)$ and the anomaly might allow to determine $m(\tilde{\nu}_\mu)$. This option should be explain the g-2 anomaly.

The following estimate demonstrates that there are hopes about this. Using the formulas of [C15] one can write the one loop contributions to the anomalous contribution $a(\mu)$ as

$$\begin{aligned} a_\mu^{\chi^0} &= \frac{m(\mu)}{16\pi^2}\sum_{i,m} X_{im} \quad , \\ X_{im} &= -\frac{m(\mu)}{12m^2(\tilde{\mu}_m)}\left[|n_{im}^L|^2 + |n_{im}^R|^2\right] F_1^N(x_{im}) + \frac{m(\chi_i^0)}{3m^2(\tilde{\mu}_m)} Re\left[n_{im}^L n_{im}^R\right] F_2^N(x_{im}) \quad , \end{aligned} \tag{4.10}$$

and

$$\begin{aligned} a_\mu^{\chi^\pm} &= \frac{m(\mu)}{16\pi^2}\sum_{k} X_{k} \quad , \\ X_{k} &= -\frac{m(\mu)}{12m^2(\tilde{\nu}_\mu)}\left[|c_k^L|^2 + |c_k^R|^2\right] F_1^C(x_k) + \frac{2m(\chi_k^\pm)}{3m^2(\tilde{\nu}_\mu)} Re\left[c_k^L c_k^R\right] F_2^C(x_k) \quad . \end{aligned} \tag{4.11}$$

Here $i = 1, ..., 4$ denotes neutralino indices which should reduce to two if also Higgsinos disappear from the spectrum. $k = 1, 2$ denotes the neutral and charginos indices reducing to single index now. $m = 1, 2$ denotes smuon index. Note that TGD suggests strongly that the masses of $\tilde{\mu}_R$ and $\tilde{\mu}_L$ are degenerate. The matrices n^L_{im}, n^L_{im} and c^L_k and c^R_k relate to the mixing of mass eigenstates and are given explicitly in MSSM [C15].

The kinematic variables are defined as the mass ratios $x_{im} = m^2(\chi^0_i)/m^2(\tilde{\mu}_m)$ and $x_k = m^2(\chi^{\pm}_k)/m^2(\tilde{\nu}_\mu)$ and the loop functions are given by

$$\begin{aligned}
F_1^N(x) &= \frac{2}{(1-x)^4}\left[1 - 6x + 3x^2 + 2x^3 - 6x^2 log(x)\right] \ , \\
F_2^N(x) &= \frac{3}{(1-x)^3}\left[1 - x^2 + 2x log(x)\right] \ , \\
F_1^C(x) &= \frac{2}{(1-x)^4}\left[2 + 3x - 6x^2 + x^3 + 6x log(x)\right] \ , \\
F_2^C(x) &= \frac{3}{(1-x)^3}\left[-3 + 4x - x^2 - 2log(x)\right] \ .
\end{aligned} \tag{4.12}$$

If one does not assume any relationship betwen sneutrino and charged slepton masses then for $m(\tilde{\nu}_\mu)/m(\tilde{\mu}) << 1$, $m(\mu)/m(\chi^{\pm}) << 1$, and $m(\chi^0_k)/m(\tilde{\mu}) << 1$ the functions F_1^N and $F_2^N(x)$ are in good approximation constant and the corresponding contributions are negligible. One has $F_1^C(x) \simeq 1/x$ and $F_2^C(x) \simeq 3/x$. It rurns out that the terms proportional to $F_1^C(x)$ and $F_2^C(x_k)$ are of the same order of magnitude. If Higgsinos do not belong to the spectrum one has $U_{k2} = 0$ giving $V_{k1}U_{k2} = 0$ leaving only the F_1^C contribution.

Consider now the mixing matrices for sfermions.

1. One has

$$\begin{aligned}
c^L_k &= -g_2 V_{k1} \ , \ c^R_k = y_\mu U_{k2} \ , \\
y_\mu &= \frac{m(\mu)}{m(W)}\frac{g_2}{\sqrt{2}cos(\beta)} \ , g_2 = \frac{e}{sin(\theta_W)} \ .
\end{aligned} \tag{4.13}$$

   Here the index k refers to the mixed states of L and R type sfermions. Since they are formed from fermion and right-handed neutrino, one expects that at higher energies the mixing is negligible. Mixing is however present and induced by the mixing of right and left handed fermion so that the mixing matrices are non-trivial at low energies and give relate closely to the massivation of sfermions and fermions.

2. One obtains

$$\begin{aligned}
c^L_k c^R_k &= -g_2^2 \frac{m(\mu)}{m(W)}\frac{1}{\sqrt{2}cos(\beta)} V_{k1}U_{k2} = -\frac{m(\mu)}{m(W)} \times \frac{4\pi\alpha}{sin^2(\theta_W)} \times \frac{1}{\sqrt{2}cos(\beta)} V_{k1}U_{k2} \ , \\
|c^L_k|^2 + |c^R_k|^2 &= g_2^2\left[|V_{k1}|^2 + \frac{m^2(\mu)}{m^2(W)}\frac{1}{2cos^2(\beta)}|U_{k2}|^2\right] \ .
\end{aligned} \tag{4.14}$$

Using these results one obtains explicit expressions for the two terms in a_μ.

1. The expressions for the term resulting from mixing of right and left handed sfermions is given by

$$\begin{aligned}
a_\mu^{mix,k} &= \frac{m(\mu)}{8\pi^2 m(\chi^{\pm}_k)} \sum_k Re[c^L_k c^R_k] \\
&= \frac{1}{8\pi^2}\frac{4\pi\alpha}{sin^2(\theta_W)\sqrt{2}cos(\beta)}\frac{m^2(\mu)}{m(W)m(\chi^{\pm}_k)} Re[V_{k1}U_{k2}] \ .
\end{aligned} \tag{4.15}$$

2. Second term is diagonal and non-vanishing also when Higgsino is absent from the spectrum.

$$a_\mu^{diag,k} = \frac{1}{8\pi^2}\frac{m^2(\mu)}{m^2(\chi^\pm)}\left[|c_k^L|^2 + |c_k^R|^2\right] \quad . \qquad (4.16)$$

Note that $|c_k^R << c_k^L$ holds true unless $cos(\beta)$ is very small.

3. The ratio of the contributions is

$$|\frac{a_\mu^{diag,k}}{a_\mu^{mix,k}}| = \frac{m(W)}{m(\chi^\pm)_k}\sqrt{2}cos(\beta)\times|\frac{V_{k1}}{U_{k_2}}| \quad . \qquad (4.17)$$

For $c_k^R = 0$ (no Higgsino) one has

$$a_\mu \simeq a_\mu^{diag,k} = \frac{1}{8\pi^2}\frac{m^2(\mu)}{m^2(\chi^\pm)}\sqrt{2}cos(\beta)\frac{4\pi\alpha}{sin^2(\theta_W)}|V_{k1}|^2 \quad . \qquad (4.18)$$

The dependence on the mass of muonic sneutrino disappears so that one cannot conclude anything about its value in this approximation. a_μ is determined by the mass scale of $\tilde{W}$, which should be of the same order of magnitude as W boson mass. The sign of the diagonal term is positive so that this contribution gives to g-2 a contribution which is of correct sign. This encourages to consider the option for which Higgsinos disappear from the spectrum.

The experimental value of the anomaly is equal to $\Delta a_\mu \simeq 23.9\times 10^{-10}$. The order of magnitude estimate obtained by assuming $(cos(\beta) = 1/\sqrt{2}, V_{k1} = 1, U_{k2} = 0)$ one obtains $a_\mu = 82.7\times 10^{-10}\times (m(W)/m(\chi^\pm)^2$, which for $m(W)/m(\chi^\pm) = 1$ is roughly 3.46 times larger than the anomaly. The p-adic scaling $k(\tilde{W}) = 89 \rightarrow k(\tilde{W}) - 2 = 87$ would give a value of a_μ near to the observed one. The mass of $\tilde{W}$ would be 160.8 GeV. Clearly the TGD inspired view about SUSY leads to a remarkably simple picture explaining the g-2 anomaly.

4. Basic differences between MSSM and TGD

The basic differences between TGD and MSSM [B2] and related approaches deserve to be noticed (see also the article about the experimental side [C11]). If Higgses and Higgsinos are absent from the spectrum, SUSY in TGD sense does not introduce flavor non-conserving currents (FNCC problem plaguing MSSM type approaches). In MSSM approach the mass spectrum of superpartners can be only guessed using various constraints and in a typical scenario masses of sfermions are assumed to be same in GUT unification scales so that at long length scales the mass spectrum for sfermions is inverted from that for fermions with stop and stau being the lightest superpartners. In TGD framework p-adic thermodynamics and the topological explanation of family replication phenomenon changes the situation completely and the spectrum of sfermions is very naturally qualitatively similar to that of fermions (genus generation correspondence is the SUSY invariant answer to the famous question of Rabi "Who ordered them?" !). This is essential for the explanation of g-2 anomaly for instance. Note that the experimental searches concentrating on finding the production of stop or stau pairs are bound to fail in TGD Universe.

Another key difference is that in TGD the huge number of parameters of MSSM is replaced with a single parameter- the universal coupling characterizing the decay

sparticle $\rightarrow$ particle+right handed neutrino,

which by its universality is very "gravitational". The gravitational character suggests that it is small so that SUSY would not be badly broken meaning for instance that sparticles are rather long-lived and R-parity is a rather good symmetry.

One can try to fix the coupling by requiring that the decay rate of sfermion is proportional to gravitational constant G or equivalently, to the square of CP_2radius

$$R \simeq 10^{7+1/2}(\frac{G}{\hbar_0})^{1/2} \quad .$$

Sfermion-fermion-neutrino vertex coupling to each other same fermion M^4 chiralities involves the gradient of the sfermion field. Yukawa coupling - call it L - would have dimension of length. For massive fermions in M^4 it would reduce to dimensionless coupling g different M^4 chiralities. In equal mass case g would be proportional to $L(m_1+m_2)/\hbar$, where m_i are the masses of fermions.

1. For the simplest option L is expressible in terms of CP_2 geometry alone and corresponds to

$$L = kR \ .$$

   k is a numerical constant of order unity. $\hbar_0$denotes the standard value of Planck constant, whose multiple the effective value of Planck constant is in TGD Universe in dark matter sectors. The decay rate of sfermion would be proportional to

$$k^2R^2(\frac{M}{hbar})^3 \simeq k^2 \times 10^7 \times \frac{G}{\hbar_0} \times (\frac{M}{\hbar})^3 \ ,$$

   where M is the mass scale characterizing the phase space volume for the decays of sfermion and is given by the mass of sfermion multiplied by a dimensionless factor depending on mass ratios. The decay rate is extremely low so that R-parity conservation would be an excellent approximate symmetry. In cosmology this could mean that zinos and photinos would decay by an exchange of sfermions rather than directly and could give rise to dark matter like phase as in MSSM.

2. Second option carries also information about Kähler action one would have apart from a numerical constant of order unity $k = \alpha_K$. The Kähler coupling strength

$$\alpha_K = \frac{g_K^2}{4\pi \times \hbar_0} \simeq 1/137$$

   is the fundamental dimensionless coupling of TGD analogous to critical temperature.

3. For the option which "knows" nothing about CP_2 geometry the length scale would be proportional to the Schwartchild radius

$$L = kGM \ .$$

   In this case the decay rate would be proportional to $k^2G^2M^2(M/\hbar)^3$ and extremely low.

4. The purely kinematic option which one cannot call "gravitational" "knows" only about sfermion mass and f Planck constant, and one would have

$$L = k \times \frac{\hbar}{M} \ .$$

   The decay rate would be proportional to the naive order of magnitude guess $k^2(M/\hbar)$ and fast unlike in all "gravitational cases". R-parity would be badly broken. Again$k \propto \alpha_K$ option can be considered.

Note that also in mSUGRA gravitatational sector in short length scales determines MSSM parameters via flavor blind interactions and also breaking of SUSY via breaking of local SUSY in short scales.

4.2.5 Experimental indication for space-time super-symmetry

There is experimental indication for super-symmetry dating back to 1995 [C26]. The event involves $e^+e^-\gamma\gamma$ plus missing transverse energy $\not{E}_T$. The electron-positron pair has transversal energies $E_T = (36, 59)$ GeV and invariant mass $M_{ee} = 165$ GeV. The two photons have transversal energies (30, 38) GeV. The missing transverse energy is $\not{E}_T = 53$ GeV. The cross sections for these events in standard model are too small to be observed. Statistical fluctuation could be in question but one could also consider the event as an indication for super-symmetry.

In [C16] an explanation of the event in terms of minimal super-symmetric standard model (MSSM) was proposed.

1. The collision of proton and antiproton would induce an annihilation of quark and antiquark to selectron pair $\tilde{e}^-\tilde{e}^+$ via virtual photon or Z^0 boson with the mass of $\tilde{e}$ in the range (80, 130) GeV (the upper bound comes from the total energy of the particles involved.

2. $\tilde{e}^\pm$ would in turn decay to $e^\pm$ and neutralino χ_2^0 and χ_2^0 in turn to the lightest super-symmetric particle χ_1^0 and photon. The neutralinos are in principle mixtures of the super partners associated with γ, Z^0, and neutral higgs h (there are two of them in minimal super-symmetric generalization of standard model). The highest probability for the chain is obtained if χ_2^0 is zino and χ_1^0 is higgsino.

3. The kinematics of the event allows to deduce the bounds

$$\begin{aligned}
80 &< m(\tilde{e})/GeV < 130 \ , \\
38 &\leq m(\chi_2^0)/GeV \leq min\left[1.12m(\tilde{e})/GeV - 37, 95 + 0.17m(\chi_1^0)/GeV\right] \ , \\
m(\chi_1^0)/GeV &\leq m(\chi_2^0)/GeV \leq min\left[1.4m(\tilde{e})/GeV - 105, 1.6m(\chi_2^0)/GeV - 60\right] \ .
\end{aligned} \tag{4.19}$$

   Note that the bounds give no lower bound for $m(\chi_1^0)$ so that it could correspond to neutrino.

4. Sfermion production rate depends only on masses of the sfermions, so that slepton production cross section decouples from the analysis of particular scenarios. The cross section is at the level of $\sigma = 10$ fb and consistent with data (one event!). The parameters of MSSM are super-symmetric soft-breaking parameters, super-potential parameters, and the parameter $tan(\beta)$. This allows to derive more stringent limits on the masses and parameters of MSSM.

Consider now the explanation of the event in TGD framework.

1. For the simplest TGD inspired option both Higgs and higgsino would disappear from the spectrum in the massivation and χ_2^0 would decay to photon and neutrino so that the missing energy would consist of neutrinos.

2. By the properties of super-partners the production rate for $\tilde{e}^-\tilde{e}^+$ is predicted to be same as in MSSM for $\tilde{e} = e_R\overline{\nu}_R$. Same order of magnitude is predicted also for more exotic super-partners such as $e_L\overline{\nu}_R$ with spin 1.

3. In TGD framework it is safest to use just the kinematical bounds on the masses and p-adic length scale hypothesis. If super-symmetry breaking means same mass formula from p-adic thermodynamics but in a different p-adic mass scale, $m(\tilde{e})$ is related by a power of $\sqrt{2}$ to $m(e)$. Using $m(\tilde{e}) = 2^{(127-k(\tilde{e}))/2}m(e)$ one finds that the mass range [80, 130] GeV allows two possible masses for selectron corresponding to $p \simeq 2^k$, $k = 91$ with $m(\tilde{e}) = 131.1$ GeV and $k = 92$ with $m(\tilde{e}) = 92.7$ GeV. The bounds on $m(Z)$ leave only the option $m(\tilde{Z}) = m(Z) =$ 91.2 GeV and $m(\tilde{e}) = 131.1$ GeV.

4. In the earlier variant of the TGD inspired model the existence of Higgs was considered as a realistic option. The indirect determinations of Higgs masses from experimental data seemed to converge to two different values. The first one seemed to correspond to $m(h) = 129$ GeV and $k(h) = 94$ and second one to $m(h) = 91$ GeV with $k(h) = 95$ [K6]. The fact that

already the TGD counterpart for the Gell-Mann-Okubo mass formula in TGD framework requires quarks to exist at several p-adic mass scales [K10], suggests that Higgs can exist in both of these mass scales depending on the experimental situation. The mass of Higgsino would correspond to some half octave of $m(h)$. Note that the model allows to conclude that Higgs indeed exists also in TGD Universe although it does not seem to play the same role in particle massivation as in the standard model. The bounds allow only $k(\tilde{h}) = k(h) + 3 = 97$ and $m(\tilde{h}) = 45.6$ GeV for $m(h) = 129$ GeV. The same same mass is obtained for $m(h) = 91$ GeV. Therefore the kinematic limits plus super-symmetry breaking at the level of p-adic mass scale fix completely the masses of the super-particles involved in absence of mixing effects for sneutralinos.

To sum up, the masses of sparticles involved for the option allowing Higgs are predicted to be

$$m(\tilde{e}) = 131 \ \ GeV \ \ , \ \ m(\tilde{Z}^0) = 91.2 \ \ GeV \ \ , \ \ m(\tilde{h}) = 45.6 \ \ GeV \ \ . \qquad (4.20)$$

If Higgs and Higgsino are both eaten in the massivation, the third condition drops off. The argument to be represented below suggests that also sleptons could correspond to Mersennes and Gaussian Mersennes: this option predictions $k(\tilde{e}) = 89$ so that the mass would be 250 GeV: this excludes the proposed interpretation of the strange event.

4.3 Do X And Y Mesons Provide Evidence For Color Excited Quarks Or Squarks?

Now and then come the days when head is completely empty of ideas. One just walks around and gets more and more frustrated. One can of course make authoritative appearances in blog groups and express strong opinions but sooner or later one is forced to look for web if one could find some problem. At this time I had good luck. By some kind of divine guidance I found myself immediately in Quantum Diaries and found a blog posting with title *Who ordered that?! An X-traordinary particle?* [L1].

Not too many unified theorists take meson spectroscopy seriously. Although they are now accepting low energy phenomenology (*the* physics for the rest of us) as something to be taken seriously, meson physics is for them a totally uninteresting branch of botany. They could not care less. As a crackpot I am however not well-informed about what good theoretician should do and shouldn't do and got interested. Could this give me a problem that my poor crackpot brain is crying for?

The posting told me that in the spectroscopy of $c\bar{c}$ type mesons is understood except for some troublesome mesons christened imaginatively with letters X and Y plus brackets containing their mass in MeVs. X(3872) is the firstly discovered troublemaker and what is known about it can be found in the blog posting and also in Particle Data Tables [C4]. The problem is that these mesons should not be there. Their decay widths seem to be narrow taking into account their mass and their decay characteristics are strange: in particular the kinematically allow decays to $D\overline{D}$ dominating the decays of $\Psi(3770)$ with branching ratio 93 per cent has not been observed whereas the decay to $D\overline{D}\pi^0$ occurs with a branching fraction $> 3.2 \times 10^{-3}$. Why the pion is needed? $X(3872)$ should decay to photon and charmonium state in a predictable way but it does not.

4.3.1 Could these be the good questions?

TGD predicts a lot of exotic physics and I of course started to exclude various alternatives. First one must however try to invent a good question. Maybe the following questions might satisfy the criterion of goodness.

1. Why these exotic states appear only for mesons made of heavy quark and antiquark? Why not for light mesons? Why not for mesons containing one heavy quark and light quark? Could it be that also $b\bar{b}$ mesons could have exotic partners not yet detected? Could it be that also exotic $b\bar{c}$ type mesons could be there? Why the presence of light quark would eliminate the exotic partner from the spectrum?

2. Do the decays obey some selection rules? There is indeed this kind of rule: the numbers of c and $\bar{c}$ quarks in the final state are equal to one.

   (a) If c and $\bar{c}$ exist in the initial state and the decay involves only strong interactions, the rule holds true.

   (b) If c and $\bar{c}$ are not present in the initial state the only option that one can imagine is the exhange of two W bosons transforming d type quarks to c type quarks must be present. If this were the case the initial state should correspond to $d\bar{d}$ like state rather than $c\bar{c}$ and this looks very strange from the standard physics point of view. Also the rate for this kind of decays would be very small and it seems that this option cannot make sense.

4.3.2 Both leptons and quarks have color excitations in TGD Universe

TGD predicts that both leptons and quarks have color excitations [K13]. For leptons they correspond to color octets and there is a lot of experimental evidence for them. Why we do not have any evidence for color excited quarks? Or do we actually have?! Could these strange X: s and Y: s provide this evidence?

Ordinary quarks correspond to triality one color triplet partial waves in CP_2. The higher color partial waves would also correspond to triality one states but in higher color partial waves in CP_2. The representations of the color group are labelled by two integers (p, q) and the dimension of the representation is given by

$$d = \frac{(p+1)(q+1)(p+q+2)}{2} \quad .$$

A given $t = \pm 1$ representation is accompanied by its conjugate with the same dimension and opposite triality $t = \mp 1$. $t = 1$ representations satisfy $p - q = 1$ modulo 3 and come as (1, 0), (0, 2), (3, 0), (2, 1), with dimensions 3, 6, 10, 15, ... The simplest candidate for the color excitations would correspond to the representation $\overline{6}$. It does not correspond directly the a solution of the Dirac equation in CP_2 since physical states involve also color Kac-Moody generators [K6].

Some remarks are in order:

1. The tensor product of gluon octet with $t = 1$ with color triplet representation contains $8 \times 3 = 24$ states and decomposes into $t = 1$ representations as $3 \oplus \overline{6} \oplus 15$. The coupling of gluons by Lie algebra action can couple given representation only with itself. The coupling between triplet and $\overline{6}$ and 15 is therefore not by Lie algebra action. The coupling constant between quarks and color excited quarks is *assumed* to be proportional to color coupling.

2. The existence of this kind of coupling would explain the selection rules elegantly. If this kind of coupling is not allowed then only the annihilation of exotic quark to gluon decaying to quark pair can transform exotic mesons to ordinary ones and I have not been able to explain selection rules using this option.

The basic constraint applying to all variants based on exotic states of quarks comes from the fact that the decay widths of intermediate gauge bosons do not allow new light particles. This objection is encountered already in the model of lepto-hadrons [K13]. The solution is that the light exotic states are possible only if they are dark in TGD sense having therefore non-standard value of Planck constant and behaving as dark matter. The value of Planck constant is only effective and has purely geometric interpretation in TGD framework. This implies that a phase transition transforming quarks and gluons to their dark counterparts is the key element of the model. After this a phase transition a gluon exchange would transform the quark pair to an exotic quark pair.

4.3.3 Also squarks could explain exotic charmonium states

Supersymmetry provides an alternative mechanism. Right-handed neutrino generates super-symmetries in TGD Universe and quarks are accompanied by squarks consisting in a well-defined sense of of quark and right-handed neutrino. Super-symmetry would allow completely standard couplings to gluons by adding to the spectrum squarks and gluinos.Exactly the same selection rules result if these new states are mesonlike states from from squark and anti-squark and the exchange of gluino after the $\hbar$ changing phase transition transforms exotic meson to ordinary one and vice versa.

In the sequel it will be shown that the existence of color excited quarks or of their superpartners could indeed allow to understand the origin of X and Y mesons and also the absence of analogous states accompanying mesons containing light quarks or antiquarks.

This picture would lead to a completely new view about detection of squarks and gluinos.

1. In the standard scenario the basic processes are production of squark and gluino pair. The creation of squark-antisquark pair is followed by the decay of squark (anti-squark) to quark (antiquark) and neutralino or chargino. If R-parity is conserved, the decay chain eventually gives rise to at least two hadron jets and lightest neutralinos identifiable as missing energy. Gluinos in turn decay to quark and anti-squark (squark and antiquark) and squark (anti-squark) in turn to quark (anti-quark) and neutralino or chargino. At least four hadron jets and missing energy is produced. In TGD framework neutralinos would decay eventually to zinos or photinos and right-handed neutrino transforming to ordinary neutrino (R-parity is not conserved). This process might be however slow.

2. In the recent case quite different scenario relying on color confinement and "shadronization" suggests itself. By definition smesons consist of squarks and antisquark. Sbaryons could consist of two squarks containing right-handed neutrino and its antineutrino ($\mathcal{N} = 2$ SUSY) and one quark and thus have same quantum numbers as baryon. Note that the squarks are dark in TGD sense.

   Also now dark squark or gluino pair would be produced at the first step and would require $\hbar$ changing phase transition of gluon. These would shadronize to form a dark shadron. One can indeed argue that the required emisson of winos and zinos and photinos is too slow a process as compared to shadronization. Shadrons (mostly smesons) would in turn decay to hadrons by the exchange of gluinos between squarks. No neutralinos (missing energy) would be produced. This would explain the failure to detect squarks and gluinos at LHC.

   This mechanism does not however apply to sleptons so that it seems that the p-adic mass scale of sleptons must be much higher for sleptons than that for squarks as I have indeed proposed.

4.3.4 Could exotic charmonium states consist of color excited c and $\bar{c}$ or of their spartners?

Could one provide answers to the questions presented in the beginning assuming that exotic charmonium states consists of dark color excited c and $\bar{c}$: or more generally, a mixture of ordinary charmonium and exotic charmonium state? The mixing is expected since $\hbar$ changing phase transition followed by a gluon exchange can transform these meson states to each other. Also annihilation to gluon and back to quark pair can induce this mixing. The mixing is however small for heavy quarks for which $\alpha_s \simeq .1$ holds true. Exactly the same arguments apply to the meson like bound states of squarks and in the following only the first option will be discussed.

1. In the case of charged leptons colored excitations have have same p-adic mass scale: for τ however several p-adic mass scales appear as the model if the two year old CDF anomaly is taken seriously [K13]. Assume that p-adic mass scales - but not necessarily masses- are the same also now. This assumption might be non-sensical since also light mesons would have exotic counterparts and somehow they should disappear from the spectrum. To simplify the estimates one could even assume even that the masses are same.

2. In the presence of small mixing the decay amplitude would come solely from the small contribution of the ordinary $c\bar{c}$ state present in the state dominated by color excited pair. The two manners to see the situation should give essentially the same answer.

3. The decays would take place via strong interactions.

The challenge is to understand why the dominating decays to $D\overline{D}$ with branching fraction of 93 per cent are not allowed whereas $D\overline{D}\pi^0$ takes place. Why the pion is needed? The second challenge is to understand why X does not decay to charmonium and photon.

1. For ordinary charmonium the decay to $D\overline{D}$ could take place by the emission of gluon from either c or $\overline{c}$ which then decays to light quark pair whose members combine with c and $\overline{c}$ to form D and $\overline{D}$. Now this mechanism does not work. At least *two* gluons must be emitted to transform colored excited $c\overline{c}$ to ordinary $c\overline{c}$. If these gluons decay to light quark pairs one indeed obtains an additional pion in hadronization. The emission of two gluons instead of only one is expected to reduce the rate roughly by $\alpha_s^2 \simeq 10^{-2}$ factor.

2. Also ordinary decays are predicted to occur but with a slower rate. The first step would be an exchange of gluon transforming color excited charmed quark pair to an ordinary charmed quark pair. After the transformation to off mass shell $c\overline{c}$ pair, the only difference to the decays of charmonium states would be due to the fact that charmonium would be replaced with $c\overline{c}$ pair. The exchange of the gluon preceding this step could reduce the decay rate with respect to charmonium decay rates by a factor of order $\alpha_s^2 \simeq 10^{-2}$. Therefore also the ordinary decay modes should be there but with a considerably reduced rate.

3. Why the direct decays to photon and charmonium state do not occur in the manner predicted by the model of charmonium? For ordinary charmonium the decay proceeds by an emission of photon by either quark or antiquark. Same mechanism applies for exotic charmonium states but leads to final state which consists of *exotic* charmonium and photon. In the case of $X(3872)$ there exists no lighter exotic charmonium state so that the decay is forbidden in this order of perturbation theory. Heavier exotic charmonium states can however decay to photon plus exotic charmonium state in this order of perturbation theory if discrete symmetries favor this.

Essentially identical arguments go through if c and $\overline{c}$ are replaced with their dark spartners and exchange of gluon by the emission of gluino. The transformation of gluon to its dark variants is an essential element in the process.

4.3.5 Why the color excitations/spartners of light quarks would be effectively absent?

Can one understand the effective absence of mesons consisting of color excited light quarks or squarks if the excitations have same mass scale and even mass as the light quarks? The following arguments are for color excited quarks but they apply also to squarks.

1. Suppose that the mixing induced by $\hbar$ changing phase transition followed by a gluon exchange and annihilation is described by mass squared matrix containing besides diagonal components $M_1^2 = M_2^2$ also non-diagonal component $M_{12}^2 = \overline{M_{21}^2}$. The eigenstates of the mass squared matrix correspond to the physical states which are mixtures of states consisting of ordinary quark pair and pair of color excited quarks. The non-diagonal elements of the mass squared matrix corresponds to gluon exchange and since color interactions get very strong at low energy scales, one expects that these elements get very large. In the degenerate case $M_1^2 = M_2^2$ the mass squared eigen values are given by

$$M_\pm^2 = M_0^2 \pm |M_{12}|^2 \ . \tag{4.21}$$

2. Suppose that $M_0^2 = 0$ holds true in accordance with approximate pseudo Goldstone nature of pion and more generally all light pseudo-scalar mesons. In fact assume that this is the case before color magnetic spin-spin splitting has taken place so that in this approximation pion and ρ would have same mass $m_\pi^2 = m_\rho^2 = M_0^2$. In TGD based model for color magnetic spin-spin splitting M_0^2 energy is replaced with mass squared [K10] and M_0^2 is obtained in terms of physical masses of π and ρ from the basic formulas

$$\begin{aligned} m_\pi^2 &= M_0^2 - \frac{1}{4}\Delta \ , \ m_\rho^2 = M_0^2 + \frac{3}{4}\Delta \ , \\ M_0^2 &= \frac{m_\rho^2 + 3m_\pi^2}{2} \ , \ \Delta = m_\rho^2 - m_\pi^2 \ . \end{aligned} \tag{4.22}$$

The exotic π and ρ would have masses

$$\begin{aligned} m^2_{\pi_{ex}} &= -M_0^2 - \frac{1}{4}\Delta = m_\pi^2 - 2M_0^2 \ , \\ m^2_{\rho_{ex}} &= -M_0^2 + \frac{3}{4}\Delta = m^2_{rho} - 2M_0^2\Delta \ . \end{aligned} \tag{4.23}$$

For $m_\pi = 140MeV$ and $m_\rho = 770$ MeV the calculation gives $m_{\pi_{ex}} = i \times 685$ MeV so a tachyon would be in question. For ρ one would have $m_{\pi_{ex}} = 323$ MeV so that the mass would not be tachyonic.

One can try to improve the situation by allowing $M_1^2 \neq M_2^2$ giving additional flexibility and hopes about tachyonicity of the exotic ρ.

1. In this case one obtains the equations

$$\begin{aligned} m_\pi^2 &= M_+^2 - \frac{1}{4}\Delta \ , \ m_\rho^2 = M_+^2 + \frac{3}{4}\Delta \\ m^2_{\pi_{ex}} &= M_-^2 - \frac{1}{4}\Delta \ , \ m^2_{\rho_{ex}} = M_-^2 + \frac{3}{4}\Delta \ ., \\ M_+^2 &= \frac{M_1^2 + M_2^2}{2} + \sqrt{(\frac{(M_1^2+M_2^2}{2})^2 + M_{12}^4} = \frac{m_\rho^2 + 3m_\pi^2}{2} \ , \\ M_-^2 &= \frac{M_1^2 + M_2^2}{2} - \sqrt{(\frac{(M_1^2+M_2^2}{2})^2 + M_{12}^4} = M_+^2 - 2\sqrt{(\frac{(M_1^2+M_2^2}{2})^2 + M_{12}^4} \end{aligned} \tag{4.24}$$

2. The condition that ρ_{ex} is tachyonic gives

$$m^2_{\rho_{ex}} = M_-^2 + \frac{3}{4}\Delta < 0 \ , \tag{4.25}$$

giving

$$\begin{aligned} m_\rho^2 &< 2\sqrt{(\frac{(M_1^2+M_2^2}{2})^2 + M_{12}^4} \ , \\ M_+^2 &= \frac{M_1^2 + M_2^2}{2} + \sqrt{(\frac{(M_1^2+M_2^2}{2})^2 + M_{12}^4} = \frac{m_\rho^2 + 3m_\pi^2}{2} \ , \end{aligned} \tag{4.26}$$

3. In the parameterization $(m_1^2, m_2^2, M_{12}^2) = (x, y, z)m_\rho^2$ one obtains the conditions

$$\begin{aligned} D \equiv \sqrt{(x+y)^2 + z^2} &> 1/2 \ , \\ \frac{x+y}{2} + D = \frac{1}{2} + \frac{3}{2}\frac{m_\pi^2}{m_\rho^2} \ . \end{aligned} \tag{4.27}$$

4. These equations imply the conditions

$$\begin{aligned} x + y &< 3\frac{m_\pi^2}{m_\rho^2} \simeq .099 \ , \\ .490 &< z < .599 \ . \end{aligned} \tag{4.28}$$

The first condition implies $\sqrt{m_1^2+m^2} < 242.7$ MeV. Second condition gives $339 < M_{12}/MeV < 595.9$ so that rather stringent bounds on the parameters are obtained. The simplest solution to the conditions corresponds to $x = y = 0$ and $z = .599$. This solution would mean vanishing masses in the absence of mixing and spin-spin splitting and could be defended by the Golstone boson property of pions mass degenerate with ρ mesons.

This little calculation encourages to consider the possibility that all exotic counterparts of light mesons are tachyonic and that this due the very large mixing induced by gluon exchange (gluino exchange squark option) at low energies. It would be nice if also mesons containing only single heavy quark were tachyonic and this could be the case if the p-adic length scale defining the strength of color interactions corresponds to that of the light quark so that the mass matrix has large enough non-diagonal component. Here one must be however very cautious since experimental situation is far from clear.

The model suggests that ordinary charmonium states and their exotic partners are in 1-1 correspondence. If so then many new exotic states are waiting to be discovered.

4.3.6 The option based on heavy color excitations/spartners of light quarks

An alternative option is that color excitations/spartners of light quarks have large mass: this mass should not be however larger than the mass of c quarks if we want to explain X: s and Y: s as pairs of color excitations of light quarks. Suppose that the p-adic mass scale is same as that for c quarks or near it (not that the scales come as powers of $\sqrt{2}$). This raises the question whether exotic $c\overline{c}$ mesons really consist of exotic c and $\overline{c}$: why not color excitations of u, d, s and their antiquarks? As a matter fact, we cannot be sure about the quark content of X and Y mesons. Could these states be $d\overline{d}$ and $u\overline{u}$ states for their color excitations? It however seems that the presence of two W exchanges makes the decay rate quite too low so that this option seems to be out of question.

One can however consider the option in which the squarks associated with light quarks are heavy. This option is indeed realized in standard SUSY were the mass scales of particles families are inverted so that stop and sbottom are the lightest squarks and super-partners of u and d the heaviest ones. This would would predict that the smesons associated with $\overline{t}$ and $b\overline{b}$ are lighter than X and Y (s)mesons. This option does not look at all natural in TGD but of course deserves experimential checking.

4.3.7 How to test the dark squark option?

The identification of X and Y as dark smesons looks like a viable option and explains the failure to find SUSY at LHC if shadronization is a fast process as compared to the selectro-weak decays. The option certainly deserves an experimental testing. One could learn a lot about SUSY in TGD sense (or maybe in some other sense!) by just carefully scanning the existing data at lower energies. For instance, one could try to answer the following questions by analyzing the already existing experimental data.

1. Are X and Y type mesons indeed in 1-1 correspondence with charmonium states? One could develop numerical models allowing to predict the precise masses of scharmonium states and their decay rates to various final states and test the predictions experimentally.

2. Do $b\overline{b}$ mesons have smesonic counterparts with the same mass scale? What about B_c type smesons containing two heavy squarks?

3. Do the mesons containing one heavy quark and one light quark have smesonic counterparts? My light-hearted guess that this is not the case is based on the assumption that the general mass scale of the mass squared matrix is defined by the p-adic mass scale of the heavy quark and the non-diagonal elements are proportional to the color coupling strength at p-adic length scale associated with the light quark and therefore very large: as a consequence the second mass eigenstate would be tachyonic.

4. What implications the strong mixing of light mesons and smesons would have for CP breaking? CP breaking amplitudes would be superpositions of diagrams representing CP breaking for mesons *resp.* smesons. Could the presence of smesonic contributions perhaps shed light on the poorly understood aspects of CP breaking?

4.3.8 Objection against covariantly constant neutrinos as SUSY generators

TGD SUSY in its simplest form assumes that covariantly constant right-handed neutrino generates SUSY. The second purely TGD based element is that squarks would correspond to the same p-adic mass scale as partners.

This looks nice but there are objections.

1. The first objection relates to the tachyonicity needed to get rid of double degeneracy of light mesons consisting of u, d, and s quarks. Mesons and smesons consisting of squark pair mix and for large α_s the mixing is large and can indeed make second eigenvalue of the mass squared matrix negative. If so, these states disappears from spectrum. At least to me this looks however somewhat unaesthetic.

   Luckily, the transformation of second pion-like state to tachyon and disappearance from spectrum is not the only possibility. After a painful search I found experimental work [C27] claiming the existence of states analogous to ordinary pion with masses 60, 80, 100, 140, ... MeV. Also nucleons have this kind of satellite states. Could it be that one of these states is spion predicted by TGD SUSY for ordinary hadrons? But what about other states? They are not spartners: what are they?

2. The second objection relates to the missing energy. SUSY signatures involving missing energy have not been observed at LHC. This excludes standard SUSY candidates and could do the same in the case of TGD. In TGD framework the missing energy would be eventually right handed neutrinos resulting from the decays of sfermions to fermion and sneutrino in turn decaying to neutrino and right handed neutrino. The naive argument is that shadronization would be much faster process than the decay of squarks to quarks and spartners of electro-weak gauge bosons and missing energy so that these events would not be observed. Shadrons would in turn decay to hadrons by gluino exchanges. The problem with this argument is that the weak decays of squarks producing right handed neutrinos as missing energy are still there!

   This objection forces to consider the possibility that covariantly constant right handed neutrino which generates SUSY is replaced with a color octet. Color excitations of leptons of lepto-hadron hypothesis would be sleptons which are color octets so that SUSY for leptons would have been seen already at seventies in the case of electron. The whole picture would be nicely unified. Sleptons and squark states would contain color octet right handed neutrino the same wormhole throats as their em charge resides. In the case of squarks the tensor product $3 \otimes 8 = 3 + \overline{6} + 15$ would give several colored exotics. Triplet squark would be like ordinary quark with respect to color.

   Covariantly constant right-handed neutrino as such would represent pure gauge symmetry, a super-generator annihilating the physical states. Something very similar can occur in the reduction of ordinary SUSY algebra to sub-algebra familiar in string model context. By color confinement missing energy realized as a color octet right handed neutrino could not be produced and one could overcome the basic objections against SUSY by LHC.

What about the claimed anomalous trilepton events at LHC interpreted in terms of SUSY, which however breaks either the conservation of lepton or baryon number. I have proposed TGD based interpretation [K7] is in terms of the decays of W to $\tilde{W}$ and $\tilde{Z}$, which in turn decay and produce the three lepton signature. Suppose that $\tilde{W}$ and $\tilde{Z}$ are color octets and that sleptons replace the color octet excitations of leptons responsible for lepto-hadron physics [K13]. One possible decay chain would involve the decays $\tilde{W}^+ \rightarrow \tilde{L}^+ + \overline{\nu}_L$ and $\tilde{Z} \rightarrow L^+ + \tilde{L}^-$. Color octet sleptons pair combine to form lepto-pion which decays to lepton pair. This decay cascade would produce missing energy as neutrino and this seems to be the case for other options too.e could overcome the basic objections against SUSY by LHC.

This view about TGD SUSY clearly represents a hybrid of the two alternative views about X and Y bosons as composites of either color excitations of quarks or of squarks and is just one possibility. The situation is not completely settled and one must keep mind open.

4.3.9 Does one really obtain pseudo-scalar smesons?

The critical question is whether one obtains pseudo-scalar states as meson-like bound states of squarks. This depends on what one means with squarks. Also the notion of pseudo-scalar is not the same for $M^4 \times CP_2$ and M^4. In TGD framework M^4 (pseudo–)scalars constructed from fermions and anti-fermions are replaced by CP_2 (pseudo–)vectors since the chiral symmetry for $M^4 \times CP_2$ implying separate conservation of lepton and baryon numbers implies that genuine fermionic H-scalars and pseudo-scalars would have quantum numbers of leptoquark.

1. The first question is what one means with ordinary pseudo-scalar mesons in TGD framework. These mesons should be characterized by a bi-local quantity which behaves like a preferred CP_2 pseudo-vector and therefore like M^4 pseudo-scalar. One should identify a unique direction of CP_2 polarization mathematically analogous to Higgs vacuum expectation value and construct a bilinear in quark wave functions associated with the partonic 2-surfaces assigned to the quarks. The problem is however that CP_2 is not a flat space. Also non-locality is a problem. Somehow one should be able to construct general coordinate invariant quantities with well-defined transformation properties under discrete symmetries.

2. The effective 2-dimensionality implying the notions of partonic 2-surfaces and string world sheets suggests a solution to the non-locality problem. Also the experience with QCD suggests that bilinear expression contains a non-integrable phase factor U connecting quark and anti-quark ad defined by the classical color gauge potentials which are just projections of SU(4) Killing vector fields to the space-time surface. The curve would be analogous to a string connecting the partonic 2-surfaces and fixed uniquely by the strong form of holography in turn reducing to the strong form of general coordinate invariance. TGD indeed predicts the existence of string world sheets and thus strings at the 3-D ends of space-time sheets defined by causal diamond.

3. What about the preferred CP_2 vector?

   (a) The first candidate is the quantity $X = I_3 j_3^{Ak}\Gamma_k + Y j_Y^{Ak}\Gamma_k$ where I_3 and Y denote color isospin and hyper-charge of the quark and j_i^{Ak} corresponding Killing vectors. The preferred vector would be due to the choice of quantization axes. This option is natural for in the case of quark bilinears but fails for a bilinear constructed from covariantly constant right handed neutrino.

   (b) Second candidate would the CP_2 part for the trace of the second fundamental form contracted with CP_2 gamma matrices -denote it by $X = H^k\Gamma_k$ -at the either end of the string connecting fermion and anti-fermion at partonic 2-surfaces. This option would be natural for the right-handed neutrino. Bi-local super-generators would vanish when the partonic 2-surface is minimal surface. This would be analogous to the representations of SUSY for which $2^{-k}\mathcal{N}$ generators annihilate the physical states and act as pure gauge symmetries.

4. This would suggest that the basic invariants in the construction is the quantity $\overline{\Psi}_1 UXO\Psi_2$. Sub-script $i = 1, 2$ refers to the partonic 2-surface, X can occur at both ends and γ_5 guarantees pseudo-scalar property. O is $1 \pm \gamma_5$ for right- *resp.* left-handed quarks. The recipe would apply also to the bilinears formed right-handed neutrinos: now only the projector $(1 + \gamma_5)$ to right-handed neutrino appears so that only single state is obtained.

Most of the options that one can imagine give something else that pseudo-scalar smeson.

1. Assuming that $\mathcal{N} = 2$ symmetry is not too badly broken, one can add to the partonic 2-surface carrying quark either right-handed neutrino or anti-neutrino or both so that one obtains a 4-plet containing two quark states, spin zero squark and and spin 1 squark. From these states one can construct meson like states.

   (a) The first implication is degeneracy of quark like states because of the presence of neutrino pair. TGD however predicts large breaking of SUSY. According to the arguments of [K5] the state containing right handed neutrino pair has propagator behaving like $1/p^3$ and does not correspond to ordinary particle. It is not at all clear whether this kind squarks can give rise to meson like states. Also the R-parity of these squarks would be +1 and the model requires negative R-parity.

(b) For spin one squarks one obtains pseudo-vector state with spin 1: the smeson state would transform like the cross product of the vectors characterizing spin 1 squarks. These states could be also present in the spectrum although they do not correspond to pseudo-scalars.

This suggests that $\mathcal{N}=2$ SUSY is badly broken and one must restrict the consideration to $\mathcal{N}=1$ option.

2. For $\mathcal{N}=1$ option both squarks are scalars (quark plus anti-neutrino option).

   (a) Forgetting the non-locality and regarding partonic 2-surfaces as basic objects as a whole, one has bound state of scalar squarks and the possible meson-like state is most naturally a scalar rather than pseudo-scalar.

   (b) Non-locality brought in by strings however changes the situation. One could construct a pseudo-scalar by starting from pseudo-scalar meson constructed by using the non-local recipe. To add neutrino and anti-neutrino at the partonic 2-surfaces one could use the bilinears $\overline{\nu}_{R,1}H^k\Gamma_k\nu_{R,2}$ and $\overline{\nu}_{R,2}H^k\Gamma_k\nu_{R,1}$ to obtain the needed right-handed CP_2 current, which is neither scalar nor pseudo-scalar. The stringy picture (braids as representation of many fermion states) forced by the strong from of general coordinate invariance (or strong form of holography or effective two-dimensonality) would be absolutely essential for this picture to work.

To sum up, it is not completely clear whether the squark option really gives pseudo-scalar smesons. One cannot exclude additional pseudo-vector states and scalars unless $\mathcal{N}=2$ SUSY is badly broken. The option based on color excitations in turn predicts only pseudo-scalar smesons but also for this option a non-local state construction is needed.

4.3.10 What are the implications for M_{89} hadron physics?

Lubos Motl told about the latest information concerning Higgs search. It is not clear how much these data reflect actual situation [C1]. Certainly the mass values must correspond to observed bumps. The statistical significances are *expected* statistical significances, not based on real data. Hence a special caution is required. At 4.5/fb of data one has following bumps together with their expected statistical significance:

- 119 GeV: 3 sigma
- 144 Gev: 6 sigma(!)
- 240 GeV: 4.5 sigma
- 500 GeV: 4 sigma

It is interesting to try to interpret these numbers in TGD framework. The first thing to observe is that weak boson decay widths do not pose any constraints on the model and one could assume that M_{89} squarks are not dark.

1. The interpretation of 144 GeV bump

Consider first the 144 GeV state 6 sigma expected significance, which is usually regarded as a criterion for discovery. Of course this is only expected statistical significance, which cannot be taken seriously.

1. 144 GeV is exactly the predicted mass of the pion of M_{89} hadron physics which was first observed by CDF and then decided to be a statistical fluctuation. I found myself rather alone while defending the interpretation as M_{89} pion in viXra log and trying to warn that one should not throw baby with the bath water.

2. From an earlier posting of Lubos Motl one learns that 244 GeV state must be CP odd -just like neutral pion- and should correspond to A_0 Higgs of SUSY. Probably this conclusion as well as the claimed CP even property of 119 GeV state follow both from the assumption that these states correspond to SUSY Higgses so that one must not take them seriously.

3. The next step before TGD will be accepted is to discover that this state cannot be Higgs of any kind.

2. Possible identification of the remaining bumps

Could the other bumps correspond to the pseudo-scalar mesons of M_{89} hadron physics? For only a week ago I would have answered "Definitely not" ! Could the claimed bumps explained by assuming that also M_{89} quarks have either color excitations or super partners with the same mass scale and the same mechanism is at work for M_{89} mesons as for ordinary mesons. The same question can be made for the option based on color excitations of quarks in $\overline{6}$ or 15.

Consider now the possible identification of the remaining Higgs candidates concentrating for definiteness to the squark option.

1. In the earlier framework there was no identification for meson like states below 144 GeV. The discovery of this week was however that squarks could have the same p-adic mass scale as quarks and that one has besides mesons also smesons consisting of squark pair as a consequence. Every meson would be accompanied by a smeson. Gluino exchange however mixes mesons and smesons so that mass eigenstates are mixtures of these states. At low energies however the very large non-diagonal element of mass squared matrix can make second mass eigenstate tachyonic. This must happen for mesons consisting of light quarks. This of course for the M_{107} hadron physics familiar to us.

2. Does same happen in M_{89} hadron physics? Or is the non-diagonal element of mass squared matric so small that both states remain in the spectrum? Could 119 GeV state and 144 GeV state correspond to the mass eigenstates of supersymmetric M_{89} hadron physics? If this is the case one could understand also this state.

3. What about 240 GeV state? The proposal has been that selectron corresponds to M_{89}. This would give it the mass 262.14 GeV by direct scaling; $m(selectron) = 2^{(127-89)/2}m(electron)$. This is somewhat larger than 240 GeV.

   Could this state correspond to spartner of the ρ_{89} consisting of M_{89} squarks. There is already earlier evidence for bumps at 325 GeV interpreted in terms ofρ_{89} and ω_{89}. The mass squared difference should be same for pionic mass eigenstates and ρ_{89} like mass eigenstates. This would predict that the mass of the second ρ like eigenstate is 259 GeV, which is not too far from 240 GeV.

   Tommaso Dorigo's newest posting The Plot Of The Week - The 327 GeV ZZ Anomaly [C8] tells about further support about ZZ anomaly at 327 GeV, which in TGD framework could be interpreted in terms of decays of the neutral member of ρ_{89} isospin triplet or ω_{89}, which is isospin singlet. A small splitting in mass found earlier is expected unless this decay corresponds to ω_{89}. Also WZ anomaly is predicted.

4. What about the interpretation of 500 GeV state? The η' meson of M_{107} hadron physics has mass 957.66 MeV. The scaling by 512 gives 490.3 GeV- not too far from 500 GeV!

The alternative option replaces squarks with their color excitations. The arguments are identical in this case. Many other pseudo-scalar mesons states are predicted if either of these options is correct. In the case of squark option one could say that also SUSY in TGD sense has been discovered and has been discovered in ordinary hadron physics for 8 years ago! SUSY would not reveal itself via the usual signatures since shadronization would be faster process than the decay of squarks via emission of selectro-weak bosons.

All these looks too good to be true. I do not know how the *expected* significances are estimated and how precisely the mass values correspond to experimental data. In any case, if these states turn out to be pseudo-scalars, one can say that this is a triump for TGD. Combining this with the neutrino super-luminality which can be explained easily in terms of sub-manifold gravitation, the prospects for TGD to become the next TOE are brighter than ever.

4.4 Strange Trilepton Events At CMS

Lubos Motl reports that CMS sees SUSY-like trilepton excesses. Also Matt Strassler tells about indications that something curious has been detected at the Large Hadron Collider [C25]. Probably a statistical fluctuation is in questions as so many times earlier. The dream to discover SUSY ieasily leads to mis-interpretations. Trilepton events however provide an excellent opportunity to learn about SUSY in TGD framework.

4.4.1 The recent view about TGD SUSY briefly

Before continuing it is good to say something about what SUSY in TGD Universe might mean and also about expected masses of squarks and sleptons as well as intermediate gauge bosons in TGD Universe. The picture is of course preliminary and developing all the time in strong interaction with experimental input from LHC so that there is no guarantee that I agree with this view for the rest of my life.

1. Super-partner of the particle is obtained by adding a the partonic 2-surface a parallelly moving right-handed neutrino or antineutrino so that one has $\mathcal{N} = 1$ SUSY. It must be emphasized that one has higher SUSYs but they are badly broken. Allowing both right-handed neutrino and antineutrino one obtains $\mathcal{N} = 2$ SUSY and interpreting all fermionic oscillator operators as generators of SUSY one obtains badly broken SUSY with rather large $\mathcal{N}$, which is however finite by finite measurement resolution inducing a cutoff on the number of fermionic oscillator operators.

2. R-parity is broken in TGD SUSY since sparticle can decay to particle and neutrino. Therefore all neutral sparticles manifesting themselves as missing energy in TGD framework eventually decay and produce neutrinos as the eventual missing energy. The decay rates to particles and neutrinos can however be so slow that photino and sneutrinos leave the reactor volume before decaying.

3. The basic assumption is that particle and sparticle obey the same mass formula apart from p-adic mass scale that can be different. For instance, the masses of sleptons are half-octaves of lepton masses. This breaking of SUSY is extremely elegant and is absolutely essential part of ordinary particle massivation too explaining the enormous mass scale differences between neutrinos and top quark in a natural manner.

4. I have proposed that the super-partners of M_{107} quarks (ordinary quarks) and gluon could have the same mass scale but be dark in TGD sense, in other words have Planck constant which is integer multiple of the ordinary Planck constant. This is required by the fact that intermediate gauge boson decay widths do not allow light exotic particles. This hypothesis could allow to understand the exotic X and Y mesons and also the absence of smesons containing light squarks could be understood. Since shadronization is expected to proceed much faster than selectro-weak decays of squarks, the squarks of M_{89} hadron physics need not be dark and M_{89} shadrons might be there. The fruitless search for squarks would be based on wrong signatures if this the case and already now we would have direct evidence for the squarks of M_{89} hadron physics.

5. Only the decays of electro-weak gauginos and sleptons would produce the standard signatures.

   (a) Charged sleptons must have large p-adic scales in TGD Universe. Ordinary leptons correspond to Mersenne prime M_{127}, Gaussian Mersenne $M_{G,113}$, and Mersenne prime M_{107}. If also sleptons obey this rule, they would correspond to the Mersenne primes M_{89} and Gaussian Mersennes $M_{G,n}$, $n = 79, 73$. Assuming that particle and sparticle obey the same mass formula apart from different p-adic mass scale, the masses of selectron, smuon, and stau would be about 267 GeV, 13.9 TeV, and 164.6 TeV. Only selectron is expected to be visible at LHC.

   (b) About the mass scales of sneutrinos it is difficult to say anything definite. A natural guess is that sneutrinos are relatively light so that they would be produced in the decays of sleptons and electro-weak gauginos. Same applies to photino. These particles are good candidates to missing energy unless their decay to particle plus neutrino is fast enough.

   (c) There seems to be no strong constraints to the mass scales of $\tilde{W}$ and $\tilde{Z}$. The mass scale could be even M_{89} characterizing W and Z. p-Adic length scale hypothesis predicts that the p-adic mass scale is half octave of intermediate boson mass scale and if the Weinberg angle is same the masses are half octaves of W/Z masses.

6. The most general option inspired by twistorial considerations (absence of IR divergences) and zero energy ontology is that both Higgs like states and Higgsinos and their higher spin generalizations are eaten so that the outcome is spectrum of massive states. This might have something do with the phenomenon in which some supersymmetry generators annihilate physical states. In any case the fermions at wormhole throats are always massless- even the virtual particles identified in terms of wormhole contacts consist of massless wormhole throats which can have also negative energy.

It is important to notice that trilepton events as signals for SUSY have nothing to do with squarks and gluinos for which I have proposed a non-standard interpretation in the previous postings (see this, this , this) and in the article [L1].

4.4.2 How to interpret the trilepton events in TGD framework?

Trilepton events [C23] represent the simplest SUSY signal and would be created in the decays $W \rightarrow \tilde{W} + \tilde{Z}$. The decays $Z \rightarrow \tilde{W^+} + \tilde{W^-}$ would give rise to dilepton events. Electro-weak gauginos would in turn decay and yield multi-lepton events. Neither W/Z boson nor the gauginos need to be on mass shell.

In the following I will discuss these decays taking seriously the above listed conjectures about SUSY a la TGD.

1. Obviously the situation reduces to the study of the decays of $\tilde{W}$ and $\tilde{Z}$.
   (a) For $\tilde{W}$ the decay channels are $\tilde{W} \rightarrow W + \tilde{\gamma}$ and $\tilde{W} \rightarrow L + \tilde{\overline{\nu}}_L$. W would decay to charged lepton-neutrino pair. One charged lepton would result in both cases.
   (b) For $\tilde{Z}$ the decay channels are $\tilde{Z} \rightarrow \nu + \tilde{\overline{\nu}}_L$, $\tilde{Z} \rightarrow \tilde{W}^+ + W^-$, and $\tilde{Z} \rightarrow \tilde{L} + \overline{L}$ and charge conjugates of these. For the second decay mode the decays of W^+ and $\tilde{W}^-$ produce lepton antilepton pair. For the third decay mode selectron is the most plausible slepton candidate and is expected to have rather large masses in TGD Universe (about 267 GeV and thus off mass-shell). $\tilde{L} \rightarrow L + \tilde{\gamma}$ is the most natural decay for slepton.

2. The decay cascade beginning with $Z \rightarrow \tilde{W^+} + \tilde{W^-}$ would produce 2 charged leptons (more generally even number of charged leptons) plus missing energy. Charged leptons would have opposite charges. No sleptons would be needed as intermediate states and all lepton families would be democratically represented as final states.

3. The decay cascade beginning with $W \rightarrow \tilde{W} + \tilde{Z}$ would produce 2 or 3 charged leptons plus missing energy.
   (a) For $\tilde{Z} \rightarrow \tilde{W}^+ + W^-$ option 3 charged leptons would result and there would be a complete family democracy. For this option the rate is expected to be largest.
   (b) For the option having slepton as intermediate state, the large masses for smuon and stau would favor selectron for 3 lepton events. 3-lepton events would have charge signatures −+ or ++- following from charge conservation alone. The suggested large mass for selectron would however reduce also the rate of 3 lepton events considerably. Note that the reported events have total transversal energy larger than 200 GeV.

4. In MSSM also $sZ \rightarrow \tilde{\chi}_1^0 + Z$ followed by $Z \rightarrow L^+ + L^-$ is possible so that trilepton state results. Here $\tilde{\chi}_1^0$ denotes the lightest neutral sboson and is a mixture of $\tilde{h}, \tilde{Z}$, and $\tilde{\gamma}$. If $\tilde{h}$ is not in the spectrum, then $\tilde{\gamma}$ is an excellent candidate for the lightest neutral gaugino. If the Weinberg angle is SUSY invariant the decay producing three charged leptons in this manner is not possible.

5. Photinos would decay to photons and neutrinos producing photons and missing energy. It is not clear whether this decay is fast enough to take place in the reactor volume.

To sum up, the trilepton events are possible and would be produced in the decays $\tilde{Z} \to \tilde{W} + W$ and $\tilde{W} \to e + \tilde{\gamma}$. The trilepton events involving selectron as intermediate state do not look highly plausible in TGD framework if one takes seriously the guess for the slepton mass scales.

4.4.3 More about strange trilepton events

I already told about indications for strange charged tri-lepton events at CMS. The inspiration came from a posting CMS sees SUSY-like tri-lepton excesses of Lubos Motl.

Only a few days later both Tommaso Dorigo and Lubos Motl discussed a quite recent paper telling about charged tri-lepton events observed at CMS.

1. From Tommaso Dorigo's posting one learns that three charged leptons with total mass near to Z mass have been observed. Charge conservation of course requires fourth charged lepton if the particles originate in the decay of Z as assumed and Tommaso Dorigo argues that this lepton has so low energy that it is not detected. This kind of lepton could results in an energy asymmetric decay of photon. The assumption that Z is the decaying particle might be however un-necessarily strong: it could be quite well W with almost the same mass. In this case charge conservation allows genuine charged tri-lepton event. The above discussion suggests the decay $W \to \tilde{W} + \tilde{Z}$ to be the source of charged tri-lepton events.

2. The authors of the paper propose that the reaction could be initiated by a decay of squark or gluino and necessarily involving R-parity breaking. There are two possibile options for R-parity breaking allowed by proton stability depending on whether it conserves lepton or baryon number. For lepton number violating option intermediate particle is neutralino (lightest sparticle which is stable in R-parity breaking scenarios) and for baryon number violating scenatior bino or higgsino. The R-parity violating decay of lightest spartner (neutral) would yield slepton-lepton pair and the R-parity violating decay of slepton a lepton pair plus neutrino. This would produce instead single observed lepton charged tri-lepton state. The authors do not give enough details to make possible for a non-professional to deduce what the detailed model for the process really is.

It is interesting to consider the situation in TGD framework in light of the crucial additional data (the three charged leptons have mass rather near to that of Z and therefore to that of$W$).

1. The decay of $W \to \tilde{W} + \tilde{Z}$ with the decays $\tilde{W}$ and $\tilde{Z}$ proceeding in either of the two manners discussed above would predict that the *total mass of all particles produced* is near to W mass (and therefore Z mass) and also why one obtains genuine charged tri-lepton states. The problem is that missing energy in the form of neutrinos and neutral sparticles is present and it is not at all clear why this energy should be small.

2. An option not discussed discussed above is the decay $W \to \tilde{\nu} + L$ followed by the decay $\tilde{\nu} \to L + \tilde{W}$ followed by $\tilde{W} \to L + \tilde{\nu}$ would not break R-parity and would produce $\tilde{\nu}$. Total energy would correspond to W mass but it is not clear why the missing energy assigned with $\tilde{\nu}$ should be small.

3. R-parity violation predicted by TGD however allows also to consider the direct decay $\tilde{\nu} \to L^+ + L^-$ so that there would be no missing energy. One could say that the decay is the reversal of a process in which $L^+ + L^-$ annihilates to a $\tilde{\nu}$ identifiable as a pair of neutrino and right-handed neutrino at microscopic level. All standard model quantum numbers would be conserved.

In TGD framework R-parity violation is a prediction of the theory and it would not violate either baryon or lepton number conservation. There is no need to assume undetected charged lepton since charge conservation allows charged tri-lepton final state as such without any missing energy. Obviously the TGD based model is by several orders of magnitude simpler than the model based on standard SUSY.

4.5 CMS Observes Large Diphoton Excess

LHC has started to produce data indicating that the new physics required by very general arguments indeed is there. Lubos Motl (http://motls.blogspot.com/2011/11/cms-very-large-excess-of-diphot html) told today about a preprint by CMS collaboration [C13] showing a very large excess of diphotons in proto-proton collisions. This excess is so large that only a rough systematic error can threat its status.

4.5.1 What has been observed?

The following two data bits give strong hints about what might be involved.

1. From the figure in the posting of Lubos Motl (http://motls.blogspot.com/2011/11/cms-very-large-excess-of-diphotons.html) one learns that the distribution for the difference $\Delta\phi$ for the difference of the azimutal angles with respect to the beam direction covers rather evenly the span $\Delta\phi < 2.80$ and the production rate is considerably higher than predicted by QCD calculations except near π where the production rate is smaller than the prediction. From momentum conservation one would expect $\Delta\phi \sim \pi$ in a good approximation in the cm frame of photons. Unless the resonance does not move with a very high velocity, the photons $\Delta\phi \simeq \pi$ should hold true quite generally. This gives hints about the production mechanism.

2. Figure 3 of the CMS preprint [C13] gives the differential cross section with respect to diphoton invariant mass $m_{\gamma\gamma}$ as a function of $m_{\gamma\gamma}$. The distribution has a sharp knee between 45-55 GeV. One might be able to see double peak at invariant masses about 50 GeV and 75 GeV and even third peak around 175 GeV. The differential cross section is however anomalous already around 20 GeV which serves as transverse momentum cutoff for photons

   The naive question by a non-professional is whether there could be resonance decaying to two photons with mass in this range. $\Delta\phi \sim \pi$ would be however required if the resonance does not move very fast in the cm frame of colliding protons. The cut on transversal momenta is 20 GeV making 40 GeV transversal energy and I am not absolutely sure whether this could cause the shoulder. The experimenters however speak about shoulder and certainly they would not do this if it were due to the cufoff. Therefore I will assume that the shoulder is genuine.

3. If the shoulder located roughly between 45 GeV and 75 GeV is real, it would seem that the two-photon state must be accompanied by a state with opposite momentum and roughly the same energy and thus moving in opposite direction. This suggests two states with mass(es) in the range [90, 150] GeV.

4.5.2 What could it be?

The speculation of Lubos Motl is that the decay of Higgs like state with mass around 119 GeV might explain the finding but admits that standard model Higgs should not produce any visible effect. Even worse, the so called little Higgs alternative would predict a reduction of diphoton production rate. There are also exotic explanations involving large dimensions and exotic gravitons but to my opininion these alternatives belong to the realm of bad science fiction and can be safely forgotten.

In my naive mind frame the strong knee around 55 GeV is something which I find very difficult to not interpret as a bump suggesting the presence of a meson like state. On the other hand, the distribution for $\Delta\phi$; does not fit with this simplistic picture.

What about the TGD inspired interpretation? The first interpretation that comes into mind relies on the TGD based view about SUSY, which differs considerably from the standard view.

1. As explained in [K7], TGD could allow the realization of SUSY in which quarks and squarks have same p-adic mass scale- perhaps even masses- before the mixing of hadrons and shadrons allowed by R-parity conservation. The mechanism explaining the experimental absence of squarks would be shadronization proceeding faster than the decay of squarks to quark and electroweak gaugino.

(a) In this framework the mysterious X and Y mesons accompanying charmonium states would be their super partners in a good approximation since the mixing would be small. The mixing of mesons and smesons would be however very large near confinement mass scale and make the other mixed state (identified as eigen state of mass squared matrix) tachyonic and eliminate it from the spectrum. The companion of pion would be tachyonic and excluded from spectrum: this would hold true for all smesons containing light quarks and perhaps also those containing only single light squark if the mass scale of the mass squared matrix is determined by the heavier quark and α_s by the lighter quark so that mixing is very large.

(b) A crucial assumption is that the squarks are dark in the sense of having a non-standard value of Planck constant: otherwise the decay widths of electro-weak gauge bosons would be too large. The phase transition changing the value of $\hbar$ and having a purely geometric (topological) meaning in TGD framework would accompany also the mixing process being analogous to mass insertions in the lines of Feynman graph.

2. In TGD framework the proposed view about squarks as particles having common p-adic mass scale with quark is suggested to hold true in both the ordinary M_{107}- and M_{89} hadron physics. There is however no need to assume that M_{89} squarks are dark. The pion of M_{89} hadron physics could identified as the earlier 144 GeV Higgs candidate, forgotten but mentioned again by Lubos Motl (`http://motls.blogspot.com/2011/10/cms-atlas-delivered-5-inverse.html`), would have 119 GeV bump as a lighter companion. The two states would be mixtures of pion and spion. The mass values for the bumps assigned to ρ_{89} and ω_{89} and to their spartner candidates allow to estimate the mass of the partner of π_{89}. The mass would be near to 119 GeV for which there are slight indications [K7].

How the shoulder around 45-55 GeV could be created from the decays of the partner of π_{89}- a (probably strong) mixture of pion and spion (no breaking of R-symmetry). Could the two mixtures of M_{89} pion and its spartner with masses (say) 119 GeV and 144 GeV (one should not take these number too literally) be responsible for the effect as the indications about two peaked structure suggest? Could the spionic parts of the states produce the events diphoton events.

1. The simplest Feynman diagram for the decay of the pion-like state would describe the turn around of squark backwards in time via the emission of two photons. This would produce onlty $\Delta\phi \sim \pi$ events and photons with energies around 60 GeV and 72 GeV for the proposed masses 119 GeV and 144 GeV.

   Comment: 144 GeV is the estimate for the mass of $\pi^{\pm}_{89}$, one obtains 138 GeV for π^0_{89}: I have earlier neglected electromagnetic mass splitting of pions and approximated pion masses with charged pion mass 140 MeV. This scales the second mass to 69 GeV.

2. For a more complex Feynman diagram exchanged squark turning around in time would emit quark and antiquark transforming in this manner to gluino and back to squark. Another possibility is emission of two gluons. This would give photon pair and something which could be just two hadron jets if the emitted quarks and gluons transform to ordinary quarks.

3. The objection is that this model need not explain the strong concentration of diphoton invariant mass to the range 45-75 GeV since in principle 4-particle final states are in question and phase space distribution does not predict anything like this. p-Adic length scale hypothesis however suggests that the resulting quark pairs actually form a p-adically scaled down variant of the pion like state and have therefore mass, which is half of its mass. This would give rise to a resonance like behavior and impy a strong concentration of the events to the invariant masses which are one half of the mass of the mother particle.

   The p-adically scaled up quarks appear even in the TGD based model of light hadrons and produce mass formula replacing Gell-Mann-Nishijina mass formula (see this). As a matter fact, the naive prediction for the mass of M_{89} pion is just 512 times the mass of the ordinary neutral pion and gives 69.1 GeV!

4. One must also worry about overall parity conservation required if only strong and electromagnetic interactions are involved with the decay process. Pion is pseudo-scalar and the

decay of pion to two pions with scaled down mass requires parity breaking in the effective action involving the pion fields only unless the vertex contains derivatives but one cannot build a Lorentz invariant involving 4-D permutation symbol from three pion fields. Should one assume that the process breaks parity conservation and involves therefore weak interactions? Or should one assume that second scaled down pion is replaced with two pions with mass equal 1/4 the mass of the decaying pion to give parity invariant effective interaction Lagrangian as assumed in the model of CDF anomaly. This would predict also diphoton pairs with invariant masses scaled down to 22.5-40 GeV. The differential cross section is anomalous down to the 20 GeV cutoff. One should be able to resolve this issue before one can take the model seriously.

4.5.3 A connection with Aleph anomaly?

There is an old anomaly known as Aleph anomaly [C10] producing 4-jets states with *jet-jet* invariant mass of 55 GeV. According to the reference, the anomaly did not survive improved statistics. Delphi and L3 also observed 4-jet anomaly with dijet invariant mass about 68 GeV: this not too far from the mass for p-adically scaled down mass of π_{89} equal to 69.1 GeV! Remarkably, according to the above reference L3 observation survived the improvement of the statistics!

1. For more than decade ago I proposed an explanation of Aleph anomaly in terms of a meson-like state formed by p-adically scaled up variants of b quark and its antiquark [K10]. The mass of the resonance was predicted correctly using p-adic length scale hypothesis predicting that the mass of scaled up b quark is half octave of the mass of b quark.

2. The model could be generalized by replacing b quark with its super-partner if one assumes that SUSY breaking means only different p-adic mass scale. There is however an aesthetic problem (I take aesthetic arguments very seriously). The model for X and Y mesons assumed that the p-adic mass scale is same: now one should give up this assumption for b quark. The reader has probably already asked whether Aleph anomaly and the recent CMS anomaly could correspond to the same meson like state. 4-jets could be produced when $\tilde{b}$ and $\tilde{b}^*$ decay to bb^* pair by emission of gluinos which then exchange quark to produce quark pair or gluon pair. In the decays of X and Y mesons the resulting quark pair would form pion or some other meson. Now two quark or gluon jets by exchanged gluinos would be produced giving altogether four jets.

3. CMS anomaly suggests a different interpretation. Perhaps the 4-jets with di-jet energies around 55 GeV and 68 GeV are produced by the decays of the mixtures of M_{89} pion and spion with masses around 110 GeV and 144 GeV producing as intermediate state the 2-adically scaled down pions with half of their original masses.

   The same mechanism is assumed also in themodel of CDF anomaly discovered for three years ago but already forgotten [K13]. Political memory is short! The mechanism would be a modification of that producing the diphoton excess. Squark and anti-squark would transform to quark-antiquark pair giving rise to intermediate scaled down pionlike state decaying to two jets with invariant mass concentrated around the mass of pion-like state. The exchanged gluino emits quark and antiquark or two gluons. Quark antiquark state could also form a scaled down M_{89} pion before the decay to two jets. The outcome would be four jets with concentration to preferred invariant masses.

4.6 No SUSY Dark Matter And Too Small Electron Dipole Moment For Standard SUSY

LUX group has reported that one leading dark matter candidate has disappeared (`http://luxdarkmatter.org/papers/LUX_First_Results_2013.pdf`). [C14] Lubos Motl (`http://motls.blogspot.fi/2013/10/dark-matter-wars-are-over-lux-safely.html`) tells more about this. The candidate is light fermion - so called neutralino predicted by SUSY models as a candidate for dark matter. What makes it a candidate is that it stable against decays if R-parity is conserved: this implies that neutralino can disappear only via pair annihilation. This is also a further blow against $\mathcal{N} = 1$

SUSY paradigm in its standard form implying among other things the non-conservation of baryon and lepton number or both.

The result of course does not mean that there would be no dark matter. It only says that the main stream of particle physics community has been at completely wrong track concerning the nature of dark matter. As I have patiently explained year after year in this blog, dark matter is not some exotic particle this or that. Dark matter is something much deeper and its understanding requires a generalization of quantum theory to include hierarchy of Planck constants. This requires also a profound generalization of the notion of space-time time.

In particular, all standard particles can be in dark phase characterized by the value of Planck constant, and the main applications are TGD inspired quantum biology and consciousness theory since dark matter with large value of Planck constant can form macroscopic quantum phases. Also dark energy in TGD sense is something very different from the standard dark energy. Dark energy in TGD Universe corresponds to Kähler magnetic energy assignable to magnetic flux tubes carrying monopole flux. These magnetic fields need no currents to generate them, which explains why cosmos can full of magnetic fields. Superconductors at the verge of breakdown of superconductivity and even ordinary ferromagnets might carry these Kähler monopole fluxes although monopoles themselves do not exist.

The result of LUX was expected from TGD point of view and does not exclude particles dark in TGD sense. Even dark particles at the mass scale of tau lepton and even at mass scale of 7-8 GeV can be considered and the CDF anomaly reported few years ago could have explanation in terms of dark variant of tau-pion identifiable as pion like bound state of colored tau leptons: also for other leptons analogous states have been reported [K13]. The experimental signatures of this kind of particles are however very different from the dark particles that LUX was searching for and could explain some reports about evidence for dark matter in ordinary sense.

The lesson to learn is that one can find only what one is searching for in recent day particle physics. Particle phenomenologists should return to the roots. Challenging the cherished beliefs - even the beliefs about what QCD color is - is painful but is the only way to make progress.

A further blow against standard SUSY came few weeks after dark matter results. ACME collaboration has deduced a new upper boundon the electric dipole moment of electron, which is by order of magnitude smaller than the previous one (`http://arxiv.org/abs/1310.7534`) [C12]. Jester (`http://resonaances.blogspot.fi/2013/11/electric-dipole-moments-and-new-physics.html`) and Lubos Motl (`http://motls.blogspot.fi/2013/11/electron-electric-dipole-moment.html`) have more detailed commentaries.

The measurement of the dipole moment relies on a simple idea: electric dipole moment gives rise to additional precession if one has parallel magnetic and electric fields. The additional electric field is now that associated with the molecule containing electrons plus strong molecular electric field in the direction of spin quantization axes. One puts the molecules containing the electrons into magnetic field and measurex the precession of spins by detecting the photons produced in the process. The deviation of the precession frequency from its value in magnetic field only should allow to deduce the upper bound for the dipole moment.

Semiclassically the non-vanishing dipole moment means asymmetric charge distribution with respect to the spin quantization axis. The electric dipole coupling term for Dirac spinors comes to effective action from radiative corrections and has the same form as magnetic dipole coupling involving sigma matrices except that one has an additional γ_5 matrix bringing in CP breaking. The standard model prediction is of order $d_e \simeq 10^{-40} e \times m_e$: this is by a factor 10^{-5} smaller than Planck length!

The new upper bound is $d_e \simeq .87 \times 10^{-32} e \times m_e$ and still much larger than standard model prediction. Standard SUSY predicts typically non-vanishing dipole moment for electron. The estimate for the electron dipole moment coming from SUSYs and is by dimensional considerations of form $d_e = c\hbar; e \times m_e/16\pi^2 M^2$, where c is of order unity and M is the mass scale for the new physics. The Feynman diagram in question involves the decay of electron to virtual neutrino and virtual chargino and the coupling of the latter to photon before absoption.

This upper bound provides a strong restriction on "garden variety" SUSY models (involving no fine tuning to make dipole moment smaller) and the scale at which SUSY could show itself becomes of order 10 TeV at least so that hopes for detecting SUSY at LHC should be rather meager. One can of course do fine tuning. "Naturality" idea does not favor fine tunings but is not in fashion nowadays: the existing theoretical models do not simply allow such luxury. The huge differences between elementary particle mass scales and quite "too long" proton lifetime represent basic example about "non-naturality" in the GUT framework. For an outsider like me this strongly suggests that although Higgs exist, Higgs mechanism provides only a parameterization of particle masses - maybe the only possible theoretical description in quantum field theory framework treating particles as point like - and must be eventually replaced with a genuine theory. For instance, Lubos Motl does not see this fine tuning is not seen as reason for worrying too much. Personally I however feel worried since my old-fashioned view is that theoretical physicists must be able to make predictions rather than only run away the nasty data by repeated updating of the models so that they become more and more complicated.

4.7 Leptoquarks As First Piece Of Evidence For TGD Based View About SUSY?

The basic problem of TGD inspired SUSY has been the lack of experimental information allowing to guess what might be the p-adic length scale associated with sparticles. The massivation as such is not a problem in TGD: the same mass formula would be obeyed by particles and sparticles and SUSY breaking would mean only different p-adic mass scales for stable particle states. One can even consider the possibility that particles and sparticles have identical masses but sparticles have non-standard value of h_{eff} behaving therefore like dark matter.

The solution of the problem could emerge from experiments in totally unexpected manner. Indications for the existence of leptoquarks have been accumulating gradually from LHC. Leptoquarks should have same quantum numbers as pairs of quark and right-handed neutrino and would thus correspond to squarks in $\mathcal{N}=2$ SUSY of TGD.

I have written about leptoquarks as an explanation for the breaking of leptonic universality for which indications have emerged from B meson decays [K7] [L4].

Leptoquarks have received considerable attention in blogs. Both Jester (see `http://resonaances.blogspot.fi/2015/11/leptoquarks-strike-back.html`) and Lubos (see `http://motls.blogspot.fi/2015/11/leptoquarks-may-arrive-lhc-to-prove-e6.html`) have written about the topic. Jester lists 3 B-meson potential anomalies, which leptoquarks could resolve:

- A few sigma deviation in differential distribution of $B \rightarrow K^* \mu^+ \mu^-$ decays.
- 2.6 sigma violation of lepton flavor universality in $B \rightarrow D\mu^+\mu^-$ *vs.* $K \rightarrow De^+e^-$ decays.
- 3.5 sigma violation of lepton flavor universality, but this time in $B \rightarrow D\tau\nu$ *vs.* $B \rightarrow D\mu\nu$ decays.

There is also a 3 sigma discrepancy of the experimentally measured muon magnetic moment, one of the victories of QED. And old explanation has been in terms of radiative corrections brought in by SUSY. In TGD framework one can consider an explanation in terms of $\mathcal{N}=2$ SUSY generated by right-handed neutrino. It has been claimed (see `http://arxiv.org/abs/1511.01900`) that leptoquark with quantum numbers of $D\nu_R$, where D denotes D type quark actually s quark, which in TGD framework corresponds to genus $g=1$ for the corresponding partonic 2-surface, could explain all these anomalies.

An alternative model would explain the breaking of lepton universality in terms of bosonic analogs of higher fermion generations. The charge matrix of ordinary gauge boson is unit matrix in the 3-D state space assignable with the three generations representing various fermion families. Gauge bosons correspond to charge 3×3 matrices, which must be orthogonal with respect to the inner product defined by trace. Hence fermion universality is broken for the 2 higher gauge boson generations. The first guess is that the mass scale of the second boson generation corresponds to Gaussian Mersenne $M_{G,79}$ [K7] [L5].

The model for the breaking of universality in lepton pair production is in terms of $M_{G,79}$ bosons. In standard model the production of charged lepton pairs would be due to the decay of virtual W bosons appearing in self-energy loop of penguin diagram. W emits Z^0 or γ decaying to a charged lepton pair. If a virtual higher generation W_{79} boson appears in self energy loop, it can transform to W by emitting Z^0_{79} or γ_{79} decaying to lepton pair and inducing a breaking of lepton universality. Direct decays of W_{79} to $l\overline{\nu}_L$ pairs imply a breaking of lepton universality in lepton-neutrino pair production. TGD as squark.

The breaking of the universality is characterized by charge matrices of weak bosons for the dynamical SU(3) assignable with family replication. The first generation corresponds to unit matrix whereas higher generation charge matrices can be expressed as orthogonal combinations of isospin and hypercharge matrices I_3 and Y. I_3 distinguishes between tau and lower generations (third experiment) but not between the lowest two generations. There is however evidence for this (the first two experiments above). Therefore a mixing the I_3 and Y should occur.

Recently additional evidence for the existence of this kind of weak boson has emerged (see http://tinyurl.com/gqrg9zt). If I understood correctly, the average angle between the decay products of B meson is not quite what it is predicted to be. This is interpreted as an indication that Z′ type boson appears as an intermediate state in the decay.

Does the breaking of universality occurs also for color interactions? If so, the predicted M_{89} and $M_{G,79}$ hadron physics would break universality in the sense that the couplings of their gluons to quark generations would not be universal. This also forces to consider to the possibility that there are new quark families associated with these hadron physics but only new gluons with couplings breaking lepton universality. This looks somewhat boring at first.

On the other hand, there exist evidence for bumps at masses of M_{89} hadron physics predicted by scaling to be 512 time heavier than the mesons of the ordinary M_{107} hadron physics. According to the prevailing wisdom coming from QCD, the meson and hadron masses are however known to be mostly due to gluonic energy and current quarks give only a minor contribution. In TGD one would say that color magnetic body gives most of the meson mass. Thus the hypothesis would make sense. One can also talk about constituent quark masses if one includes the mass of corresponding portion of color magnetic body to quark mass. These masses are much higher than current quark masses and it would make sense to speak about constituent quarks for M_{89} hadron physics. Constituent quarks of the new hadron physics would be different from those of the standard hadron physics.

With a lot of good luck both mechanisms are involved and leptoquarks are squarks in TGD sense. If also M_{89} and M_{79} hadron make themselves visible at LCH (there are several pieces of evidence for this), a breakthrough of TGD would be unavoidable. Or is it too optimistic to hope that the power of truth could overcome academic stupidity, which is after all the strongest force of Nature?

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