Weak Gravity Unification with the Quantum Vacuum

PART II

From Scalar Tensor Theory
Towards Supergravity + Monstrous extension

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This is Part II of the original presentation by the same title. In this slideshow I will attempt to extend the domain of the theory to higher energies in the extremal gravities present at $\sim 2M_{\odot}$ neutron stars and smaller black holes. At these higher energies and stronger gravities the theory moves into *supergravity* theories. These are not quantum gravities but are the lower limit of such. Extremal gravities are still comparatively weak compared to strong space-time curvatures near singularities. The Planck energies are still relatively far away and rolled up in very small compactifications. It is not currently known where the energies of *supergravities* lie.

Prior we left off at:

$$16\,\phi^5\; m_P^2\,\frac{(\pi^{+-})^4}{m_{e^+e^-}^6} = 8.0801742479\ldots \times 10^{53} \quad \text{(Ideal, or good Codata)}$$

$$\text{If:}\quad \phi = \sqrt[2048]{\frac{1}{\sqrt[65536]{\sqrt[4]{8e}\,\alpha^4\, e^{\pi/4\alpha}\,\frac{\alpha^4}{2\pi}-1}}} \quad \text{(Low energy, Codata group)}$$

$$\text{Or:}\quad \phi = \sqrt[2048]{\frac{1}{\sqrt[65536]{\sqrt[4]{8e}\,\alpha_{nn}^4 e^{\pi/4\alpha_{nn}}\,\frac{\alpha_{nn}^4}{2\pi}-1}}} \quad \text{(Slightly higher energy, NS,BH)}$$

* NS,BH at Neutron Star level or smaller (more curvature) Black Holes

$$\phi = \sqrt[2048]{\frac{1}{\sqrt[65536]{\sqrt[4]{8e}\,\alpha^4\, e^{\pi/4\alpha}\,\frac{\alpha^4}{2\pi}} - 1}}$$

Higher energy → $$\phi = \sqrt[2048]{\frac{1}{\sqrt[65536]{\sqrt[4]{8e}\,\alpha_{nn}^4\, e^{\pi/4\alpha_{nn}}\,\frac{\alpha_{nn}^4}{2\pi}} - 1}}$$ (near to NS or BH)

Long range scalar field ϕ (x, y, z, t) in weak gravity generated by matter distribution and combination vacuum local QED , space-time curvature (inverse gravitational coupling constant $\sim 10^{38}$). Somewhat similar to Brans-Dicke Theory but with root complexed Bose-Einstein form. However, do not consider a time varying cosmology for constants (like in LNH) but for running of constants as one goes to higher energies. A natural example would be black holes getting smaller with space-time curvature getting smaller.

The scalar ϕ changes from space-time point to space-time point and stays in the range *very near* ~ 1 for our Poincare flat like space in our 'weak gravity' world. The decimal place numbers run as a computation in the space-time changes moving from point to point. The range is: 1.00033661022615… To 1.00336611192047… in our model using a $\sim 2M_{\odot}$ neutron star as an observable endpoint. This does not look like much of a change in ϕ but the information space is large for such a small vacuum energy change. However, after the weak gravity space ϕ takes on larger and larger values at even higher energies. Here is a toy model approach whereby the anti matter pairs eventually run up to the Planck energy value,

$$16\,\phi\,\frac{\left(\phi\,\pi^{+-}\right)^4}{m_P^4} = 8.0801742479\ldots \times 10^{53}$$

$$16\,\phi\,\frac{(\phi\,\pi^{+-})^4}{m_P^4} = 8.0801742479\ldots \times 10^{53}$$

$\phi\,\pi^{+-}$ is invariant, m_P is invariant

One set of the anti matter pair squared cancels with the original squared Planck energy suppression.

$$16\,\phi^5\,\frac{(\pi^{+-})^4}{m_P^4} = 8.0801742479\ldots \times 10^{53}$$

The scalar $\phi = 2.9528830 \ldots \times 10^{132}$ *(near or at a singularity)*

This probably does not manifest, as quantum gravity does not have a global symmetry. The pion mass will have long before degenerated into other states.

<u>The calculation has a limit but where?</u>

At some point before the spontaneous breaking of symmetry the *Nambu-Goldstone* bosons of QCD are massless and have a photon like behavior. Looking at our equation there is an $N \times N$ double copy nature in that there is the charged pion squared times charged pion squared. The $N = 4$ Supersymmetric Yang-Mills theory contains massless particles. We can supplant this into the equation for a higher energy form for a higher energy vacuum potentially with much symmetry.

$$(N = 4 \ \text{Super Yang-Mills}) \times (N = 4 \ \text{Super Yang-Mills})$$

The BPS states will replace the quartic antimatter pairs and the quadratic form remains for higher energy production of gamma within suppressive states of the Planck energy

$$16\,\phi^5\,\frac{m_P^2}{m_{e^+e^-}^2}\,\frac{\left(\pi^{+-}\right)^4}{m_{e^+e^-}^4} = 8.0801742479\ldots\times 10^{53}$$

Generalize to the higher energy form

$$16\,\phi^5\,\frac{m_P^2}{m_{e^+e^-}^2}\frac{\left((N = 4\ \text{Super Yang}-\text{Mills})\ \times\ (N = 4\ \text{Super Yang}-\text{Mills})\right)^2}{(BPS\ states \times BPS\ states)^2} = M$$

If, $\phi = 2.9528830\ldots\times 10^{132}$ then

a lot of jigsaw puzzle pieces might be assembled to create something beautiful…although each piece may be asymmetric

$$\phi = 2.9528830\ldots \times 10^{132}$$ [Looks suspiciously close to 10^{120}]

Instead let us stay at the lower end of the vacuum in the area of conformal scalar-tensor theory and supergravity gauge theory. where we know much symmetry takes place and pieces can be symmetric also.

$$16\,\phi^5 \frac{m_P^2}{m_{e^+e^-}^2} \frac{((N = 4\ \text{Super Yang–Mills}) \times (N = 4\ \text{Super Yang–Mills}))^2}{(BPS\ states \times BPS\ states)^2} = M$$

Where M can still be $= 8.0801742479\ldots \times 10^{53}$ without thinking about quantum gravity

The Gell-Mann, Oakes, and Renner (GMOR) mass formula states that the pion mass squared is proportional to the product of a sum of quark masses and the quark condensate.

$$m_{\pi}^{2} = \frac{(m_u + m_d)\,|\langle 0|\langle\, \bar{u}u\rangle|0\rangle|}{f_{\pi}^{2}} + O(m^2)$$

We use the charged pion mass π^{+-} instead of the constituent pion mass m_{π}

$$16\,\phi^5\, m_P^2\, \frac{\left(\pi^{+-}\right)^4}{m_{e^+e^-}^6} = 8.0801742479\ldots \times 10^{53}$$

Rewriting the equation to reflect a degenerate vacuum

$$16\,\phi^3\,\frac{m_P^2}{m_{e^+e^-}^2}\;\frac{\left(\phi\,\frac{(m_u+m_d)\,|\langle 0|\langle\,\bar{u}u\rangle|0\rangle|}{f_\pi^2}+O\left(m^2\right)\right)^2}{\gamma_{photon}^2}=8.0801742479\ldots\times 10^{53}$$

The scalar ϕ is coupled to the di-quark condensate. The scalar couples easily to boson condensates. The ratio of the Planck mass squared to the anti-matter squared suppresses not only quantum gravity effects but very large effects of gamma radiation in our low energy vacuum. This is also due to the hierarchal distance of low energy vacuum to the Planck energy cutoff.

The ratio,

$$\frac{m_P^2}{m_{e^+e^-}^2} = \frac{hc}{2\pi\, G m_{e^+e^-}^2}$$

The inverse of this ratio is the dimensionless very small number

$$7.0072\ldots \times 10^{-45}$$

Sometimes it has been referred to as a gravitational coupling constant but using the electron mass alone (not quite like this anti matter version, 4×). It is more indicative of the strength of QED compared to the strength of gravity than a gravitational coupling constant.

$$\frac{\left(\phi \ \frac{(m_u + \ m_d)\ |\langle 0|\langle\ \bar{u}u\rangle|0\rangle|}{f_\pi^2} + O(m^2)\right)^2}{\gamma_{photon}^2}$$

Is representative of the quantum vacuum due to a spontaneous symmetry breaking. Usually, $SU(2) \times SU(2)$ to $SU(2)$ for the appearance of the three *Nambu-Goldstone bosons* represented by the light mass pions. However, the virtual QED vacuum is included here as well. So it is something more for this theoretical construct. And for the low energy quantum vacuum we are only concerned for the two (virtual) charged pions and not the neutral pion.

Our vacuum from a broken symmetry is something more than just a gauge theory like $SU(2)$. It is something else. It is evidently nonphysical most of the time. How are the virtual antimatter modes related to the potential of two virtual charged pions? Scattering modes do not happen until there is something physical. It is interesting in that we are only dealing with (virtual) charged particles.

Earlier we said that $N = 4$ Super Yang-Mills is also a candidate for the vacuum energy area around conformal gravitational theory along with gauge groups. The prime candidate is…

From theory it is known that (in some ways),

$$(N = 4 \text{ Super Yang-Mills}) \times (N = 4 \text{ Super Yang-Mills}) =$$

$$\boxed{N = 8 \text{ Supergravity}}$$

$N = 8$ Supergravity is the maximal supersymmetry that supergravity theory can have. It is a lower limit of 10 dimensional superstring theory. We are interested in a 5 or 6 dimensional theory of $N = 8$ Supergravity as we want the theory to be closer to our lower energy world. There must be many symmetric pieces that work to do this.

We propose that not only is the theory supersymmetric but this supersymmetry resides within the very large Monster Group symmetry. There are probably different dimensional grades as one moves into higher energies toward 10 dimensional superstring theory. It is almost certain that we have a minimal 5D theory with KK mode scalar ϕ. This was defined in Part I of the PowerPoint presentation. We translate this to (as dual to) $N = 8$ Supergravity with 5 dimensions. $N = 8$ Supergravity (4D 5D 6D 7D 8D… or maybe it is optimal at a certain dimension) is then residing somewhere in the Monster Group symmetry.

The gauge fields in $N = 8$ Supergravity are 1 graviton, 8 gravitinos, 28 graviphotons, 56 fermions, and 70 scalars

$$1 + 8 + 28 + 56 + 70 = 163$$

The Heegner number 163 makes its appearance

The number 163 is a discriminant involved in the imaginary quadratic field of class number 1.

The famous j-invariant is used to show that

$$e^{\pi\sqrt{163}} = 262537412640768743.99999999999925\ldots$$

ties it to the Monster group.

The numbers 70 and 56 also make an auspicious appearance

$$70^2 = 4900 \quad \text{and} \quad 56^2 + 42^2 = 4900$$

Where the number 70^2 is related to a solution of a particular Diophantine equation (Edouard Lucas' cannonball problem)

$$\frac{1}{6}K(1+K)(1+2K) = N^2$$

There being only two solutions to this,

$$K = 1,\ N = 1 \quad \text{and} \quad K = 24,\ N = 70$$

An amazing property of $0^2 + 1^2 + 2^2 + 3^2 + .. + 24^2 = 70^2$ is that it is directly related to the Leech Lattice as it used in the construction of the 26 dimensional Lorentzian unimodular lattice II**25,1** using the Weyl vector:

0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24:70

The quadratic value,

$$e^{2\pi\sqrt{163}}\, 70^2$$

has elements that point to the Leech lattice and the Monster group.

Just a mention, $x^2 - x + 41$ (after Euler)

Yields primes for all values of x between 1 and 40

$$x^2 - x + 41 = 0$$

Requires the use of the square root of -163 for the solution

$$\boxed{\text{is} \quad 56^2 + 42^2 = 4900 \quad \text{related ?}}$$

$84(g-1)$ ***<u>Hurwitz's automorphism theorem</u>***

'The Monster is a Hurwitz Group' (Robert A. Wilson)

The symmetric genus of the Monster is $(2, 3, 7,) \frac{1}{42}$

There is a physical coincidence,

$$e^{2\pi\sqrt{163}}\,70^2 \sim \frac{hc}{\pi G m_n^2}$$

$$\frac{hc}{\pi G m_n^2} = \frac{m_P^2}{m_n^2}$$

where $m_n = neutron\ mass$

Actually, we propose that m_n in this relation is affected by the extreme space time curvature near or at a $\sim$2 solar mass neutron star and that this mass is a little bit more due to a <u>slight</u> increase in the vev (Part I).

Number theory becomes important near the endpoint of General Relativity where Scalar Tensor theory becomes more conformal and it may be assured that Coleman-Mandula theorem no longer applies. The 194×194 Monster complex table may degrade to higher vacuum energies, (Heegner numbers and elliptic modular functions) keeping symmetry. Supergravities or specifically $N = 8$ Supergravity reside within a manifest very large group (Monster) where symmetries are broken but the Monster still resides as (fuzzy) complete. Due to error correction codes from

$$\boldsymbol{Leech\ Lattice} \times \boldsymbol{Leech\ Lattice}$$

and the other 8, 12 dimensional groups (sphere packing theory) the Monster retains its symmetry. These codes may eventually be seen as quantum error correction codes.