

“It From Bit.”

Sakharov’s Emergence of Spacetime and Matter from Superconducting Quantum Foam

Jack Sarfatti

Internet Science Education Project¹

Abstract

The cosmological constant mystery is solved in terms of Sakharov’s implicit notion of the virtual superconducting quantum vacuum origin of inertia and spacetime curvature as phase modulation of the Goldstone condensate from a coherent quieting, or derandomizing, of zero point fluctuations from spontaneous broken symmetry giving a more stable vacuum. The anomalous acceleration of the expansion of the universe (“quintessence” Type I) and the “dark matter” are two sides of this same coin having a unified simple explanation. Dark matter, 90% of the universe’s mass is simply a configuration of Type II string defects in the superconducting vacuum. The fact that the universe has self-organized to form stars, planets and life requires the negentropic cosmic expansion of space as distinct from wrong ideas of “tired light” scattering off cosmic dust.

“this the invisible police officer of the Fates, who has the constant surveillance of me, and secretly dogs me, and influences me in some unaccountable way.”²

The phrase “It from bit” is John Archibald Wheeler’s.³ Wheeler works from Bohr’s idealism point of view that quantum reality consists only of waves without particles that are “hidden variables” in Bohm’s sense of realism. I take some liberties with Wheeler’s phrase. I posit that quantum waves are intrinsically “thought like” and that particle-hidden variables are intrinsically “rocklike” in the sense of Henry Stapp.⁴ “It” is then the “rocklike” material quality of the world. “Bit” is the “thought like” mental quality of the world in the sense of Bohm and Hiley’s “active information”⁵ of “pilot” “qubits”.⁶

¹ San Francisco, North Beach

² “Moby Dick” (1851), Chapter One “Loomings” by Herman Melville. Objective evidence of precognitive remote viewing of terror full September 11, 2001, better, or, rather, worse, than Nostradamus disinformation spread like cosmic inflation on the Internet. 150 years in advance, we find Melville writing, completely out of context, “Grand Contested Election for the Presidency of the United States.” Alluding to Bush-Gore election of 2000? Followed soon by “BLOODY BATTLE IN AFGHANISTAN.” (CAPS in Melville’s MS). “Spooky telepathic action at a distance”? (Einstein’s phrase), Yes. Violation of “subquantal heat death”, i.e. nonequilibrium of Bohm’s hidden variables (Tony Valentini), giving post-quantum “signal nonlocality” override of uncontrollable local quantum randomness? Yes. Global Consciousness Project of PEAR Lab at Princeton, brain data of Libet, Radin, Bierman relevant? Yes. Roger Penrose’s “teleology” of human consciousness? Yes. Recall allegations of “The Bible Code”. It’s not only the Bible quite obviously.

³ “Time Today” and “Physics in Knots” in “The Physical Origins of Time Asymmetry” (Cambridge, 1994)

⁴ “Matter, Mind and Quantum Mechanics”

⁵ “The Undivided Universe” (Routledge, 1993)

⁶ “Minds, Machines, and the Multiverse: The Quest for the Quantum Computer”, Julian Brown (Simon & Schuster, 2000)

Start with a quantum foam of the zero point fluctuations (ZPF) of the electro-weak-strong gauge fields fibered over the global inertial frame GIF of special relativity.⁷ Enter the Goldstone mode spontaneous symmetry breaking of this unified U(1)xSU(2)xSU(3) gauge force field⁸ and its lepto-quark sources.⁹ The Goldstone field $\phi(x)$ is a coherent phase field of a local broken order parameter $\psi(x)$ of the quantum vacuum. Real superconductors are made from real electron-electron pairs of charge $2e$. The virtual superconductor that is part of the quantum vacuum structure would then be made of virtual electron-electron pairs off the mass shell in a positive background of virtual positrons giving electrically neutral plasma. I cannot be too precise about this of course. Indeed, one might imagine this level to be dominated by a mirror or “dual” world of virtual magnetic monopole charges g obeying Dirac’s string quantization with homotopic winding number n .

$$ge \approx n\hbar c \quad (1.1)$$

In which magnetic fields are replaced by electric fields, electric super currents by magnetic super currents and the quantized flux of a vacuum vortex would be e instead of g .¹⁰ In general

$$\psi(x) = |\psi(x)| e^{i\phi(x)/\Phi_0} \quad (1.2)$$

where Φ_0 is either the usual quantized magnetic flux in an electrically superconducting quantum vacuum, or, alternatively, is the quantized electric flux of lepto-quarks as Wheeler “geon” wormhole mouths using Abdus Salam’s strong short range gravity $G^* \gg G(\text{Newton})$ over scales $\hbar/mc \sim G^*m/c^2$. The lepto-quarks look like point particles in electromagnetic deep inelastic scattering with virtual spacelike photon Heisenberg microscope probes because of the enormous elliptical space curvature at the wormhole mouth whose circumference $C \ll \hbar/mc$.

I simply heuristically posit the following toy model U(1)¹¹ semi-phenomenological “Landau-Ginzburg” closed self-referential loop set of equations for the quantum *vacuum* local coherent order suppressing random zero point fluctuations¹²

⁷ This corresponds to the perfect “world crystal lattice” of Hagen Kleinert (Free University of Berlin) in which 1-dim topological string defects of disclination and dislocation make curvature and torsion respectively. The size of a unit cell is the Planck length L_p that is variable because of the unseen hyperspace dimensions of the parallel classical material universes of Super Cosmos.

⁸ Principal fiber bundle over globally flat spacetime base space for forces and associated bundle for sources.

⁹ “The Quantum Theory of Fields”, Vol II, Steven Weinberg, 21.6 “Superconductivity” p. 332-351

¹⁰ This would explain the anomalous experimental observations of vacuum electrical charge density reported by Bo Lehnert at Vigier 2000 at UC Berkeley Faculty Club.

¹¹ This can be extended to the non-Abelian SU(2)xSU(3) Yang-Mills case.

¹² This is why the picture of deriving inertia m in $F = ma$, and gravity from purely random ZPF as suggested by Haisch, Rueda and Puthoff is entirely wrong IMO. At best, the m computed by them from random electromagnetic ZPF Lorentz force drag is a small virtual “normal fluid” or random “noise” correction to the Goldstone lepto-quark rest mass m from the coherent virtual superfluid “signal”.

$$g_{\mu\nu} D^\mu D^\nu \psi = -\frac{1}{\xi^2} \psi + L_p \left(\frac{\lambda}{\xi} \right)^2 |\psi|^2 \psi + g_{\mu\nu} \left(D^\mu - \frac{e}{\hbar c} A^\mu \right) \left(D^\nu - \frac{e}{\hbar c} A^\nu \right) \psi \quad (1.3)$$

Eq. (1.3) is the effective generally relativistically covariant Landau-Ginzburg local field equation for the inhomogeneous virtual superfluid quantum vacuum coherent ordering derandomizing the zero point fluctuations for potentially useful work.¹³ (1.3) is the “Schrodinger equation” for the giant wave function of the coherent virtual part of the quantum vacuum. Taking real and imaginary parts as in Bohm realism should give a generalized Hamilton-Jacobi equation and a current continuity equation for J_s^μ . One then posits a “pilot condition” for the motion of a volume element of virtual superfluid.

The model has 4 length scales.

- $L_p(x)$ is the variable “unit cell” Planck length of the 4-dim Kleinert “world crystal lattice”.¹⁴
- $1/\sqrt{\Lambda^*(x)}$ is the variable microscopic cosmological field length scale $\sim 10^{28}$ cm.¹⁵
- $\xi(x)$ is the variable “coherence length” of the superconducting quantum vacuum that sets the scale of variation of the modulus field $|\psi(x)|$ whose square is the local

¹³ So called “tapping of zero point vacuum energy” as reported in the December 1979 “Memorandum for the Record” from the Central Intelligence Agency on my physics research at that time. Indeed, I had mentioned this potential application to San Francisco businessman, Alvin Duskin, in 1980. This caused him, he said to me recently at the San Francisco Bay Club, to get into the alternative energy business (flywheels from Ed Teller’s Lawrence Livermore Lab). Duskin, today, runs the “Educate the Girls” Foundation at The Presidio with Lawry Chickering who ran the Reagan think-tank “Institute for Contemporary Studies” in the early 1980’s when I consulted with Lawry on SDI and possible use of quantum nonlocality for untappable submarine ship to shore communications. This was many years before current explosion of R&D in “quantum cryptography” using EPR correlated pairs of quanta.

¹⁴ This variation is from the hyperspace “anholonomic stress” on the world crystal from the unseen dimensions of superstring theory now extended to “membranes” as “M-theory”. Searches for strong short-range gravity are now underway. Experiments so far show spontaneous gravity, i.e. not metrically engineered or “stimulated”, is Newtonian with $L_p \approx 10^{-33}$ cm down to scale 0.2 millimeters. Abdus Salam introduced the idea of strong short-range “f-meson” gravity for hadrons in the early 1970’s. I worked with him at ICTP (Trieste, Italy) in 1973 to show how Regge trajectories, the key data of modern string theory, were like extreme nonradiating Kerr-Newman rotating tiny black holes with $G^* \gg G$. This idea was forgotten for 25 years. See August 2000 Scientific American “The Universe’s Unseen Dimensions” for a popular description.

¹⁵ This idea was first noted for real rotating superconductors by Giovanni Modanese that seem to act like an anti-gravity shield. This excited interest in the NASA Breakthrough Propulsion Project as a possible explanation for flying saucers seen over restricted military air space for many years. NASA does not, of course, explicitly acknowledge this as their motivation for fear of ridicule. Modanese did not think of generalizing his idea to a virtual superfluid “off mass shell” for a complex quantum vacuum structure quieting locally random zero point field fluctuations into a coherently phased order “interferogram” as I have done here. Modanese used a global Feynman path integral formulation and did not write down the intuitively appealing local geometrodynamical field equation with the quantum corrections as I do here.

number density of the cohered quantum vacuum virtual superfluid effective off-mass shell Bose-Einstein condensate component.

- $\lambda(x)$ is the variable gauge field penetration depth of the “vorticity” field that is excluded from the bulk vacuum, i.e. “Meissner effect”.

$$(\nabla \times \nabla \times A)^\mu = \left(\frac{1}{\lambda^2} \right) (D^\mu \phi - A^\mu) \quad (1.4)$$

Eq. (1.4) is essentially the covariant equation for the Meissner effect expelling 4-vorticity $(\nabla \times A)^\mu$. For an electrical superconductor the vorticity is essentially the quantized magnetic flux tubes nhc/e . The curl of the magnetic field appears in Maxwell’s field equations as the Ampere law effect of a source electric current including the vacuum displacement current that led to the discovery of transverse electromagnetic waves of radar, radio, TV, light, x-rays, gamma rays etc. The dual vacuum of magnetic monopoles adds a magnetic current to Faraday’s law of induction generating the curl of the electric field with electric flux quantized to ne , and possibly $(n/3)e$ for quarks.

$$J_s^\mu \approx \left(\frac{1}{\lambda^2} \right) (D^\mu \phi - A^\mu) \quad (1.5)$$

J_s^μ in (1.5) is the 4-dim super current density whose conservation law would be

$$D_\mu J_s^\mu = 0 \quad (1.6)$$

The semi classical quantum corrected Einstein geometrodynamical local field equation in the presence of real matter is then

$$G_{\mu\nu} + \Lambda^* g_{\mu\nu} = \frac{L_p^{*2}}{\hbar c} T_{\mu\nu} \quad (1.7)$$

where the local cosmological field is¹⁶

$$\Lambda^*(x) = L_p^*(x) |\psi(x)|^2 - \frac{1}{L_p^{*2}(x)} \quad (1.8)$$

As is well known, the random zero point fluctuations essentially make the contribution $-1/L_p^{*2}$ to the cosmological constant.¹⁷ A key mystery in physics today is

“why do the zero point energies necessarily associated with quantum fluctuations not curve spacetime?”¹⁸

¹⁶ See equation (1.26) below for the derivation. Note the factor of the fine structure constant α .

¹⁷ Pp.25-6 “Cosmological Physics”, John Peacock (Cambridge, 1999)

$$\xi = \frac{\hbar}{\sqrt{2}mc} \quad (1.9)$$

ξ is the coherence length of the modular field $|\psi(x)|$.¹⁹

$$\frac{\lambda}{\xi} = \frac{1}{\sqrt{2\alpha L_p^3} |\psi|} \quad (1.10)$$

$$L_p^* |\psi|^2 = \frac{1}{2\alpha L_p^2} \left(\frac{\xi}{\lambda} \right)^2 \quad (1.11)$$

$$\Lambda^* = L_p^* |\psi|^2 - \frac{1}{L_p^2} = \frac{1}{L_p^2} \left(\frac{1}{2\alpha} \left(\frac{\xi}{\lambda} \right)^2 - 1 \right) \quad (1.12)$$

The key is the relative change of sign²⁰ of $\Lambda^*(x)$ in different regions of space. The random virtual “normal fluid” component of the quantum vacuum “gravitates”. The coherent nonrandom virtual “superfluid” component “anti-gravitates”. The threshold of classical cosmology is when these two opposing quantum effects cancel out. We see in equation (1.8) that the key control parameter is the ratio ξ/λ of coherence to penetration depth.²¹ Two cases,

- $\xi/\lambda > \sqrt{2\alpha}$ Type I string vortex defect of world crystal is inner cylinder core of almost normal unbroken symmetry inside of which the vorticity drops to zero. An outer annular cylinder in which $|\psi|$ rises to an asymptote. Type I defects are not energetically favored. $\Lambda^* > 0$, therefore the Type I superconducting vacuum has “quintessence”, i.e., a repulsive cosmological field that would, for example, at the right scale and configuration, accelerate the expansion of the universe relative to what it is for zero cosmological constant. This effect has now been allegedly measured.
- $\xi/\lambda < \sqrt{2\alpha}$ Type II string vortex defect of world crystal is inner cylinder core of uniform vorticity flux inside of which $|\psi|$ rises to its asymptote. There is a range of

¹⁸ “Fluctuation-Dissipation Theorem in Relativity and Cosmological Constant”, E. Mottola, “Time Asymmetry” cited in footnote 2 above.

¹⁹ i.e., distance over which the modular field significantly changes.

²⁰ The physical meaning of the sign depends on signature convention.

²¹ I published papers in Physics Letters in 1967, while a professor at San Diego State, on “self-trapped laser filaments” in nonlinear optics. Ray Chiao (UC Berkeley) told Charles Townes, in my presence, that he read this paper of mine when he started experimental research on these filaments.

applied vorticity that energetically favors the formation of these defects. $\Lambda^* < 0$, therefore gravitating dark matter is simply the formation of Type II string defects in the superconducting vacuum. More than 90% of the effective mass of the universe is in this form.

The completely normal random ZPF Haisch-Rueda-Puthoff type vacuum is actually higher in *energy density* than the superfluid vacuum by the amount

$$\Delta = \frac{\hbar c}{L_p^*} |\psi|^2 \quad (1.13)$$

$$T_{\mu\nu}(x) = 0 \quad (1.14)$$

is the vanishing of the stress-energy density tensor of real matter on the mass shell for the classical vacuum.

$$\theta = \frac{\phi}{\Phi_o} \quad (1.15)$$

θ is the dimensionless scalar field “Bit” quantum coherent phase *from* which we derive the classical geometrodynamical field “It”. ϕ is the Goldstone phase field with the dimensions of the magnetic flux quantum Φ_o if the virtual superconducting quantum vacuum is the electrical type.²²

$$u_\mu = \partial_\mu \left(L_p^2 \left(\theta - \frac{e}{\hbar c} A_\mu \right) \right) \quad (1.16)$$

$u_\mu(x)$ is the local distortion field of the Kleinert world crystal lattice. It is the infinitesimal translation of Einstein’s holonomic general coordinate transformations encapsulating the local strong equivalence principle.²³ Note that $\frac{e}{c} A_\mu$ is the electromagnetic field momentum.²⁴

The Regge trajectory formula from hadronic resonances as string vibrations also, I conjecture, works for the electron, i.e.,

²² If the vacuum is made of virtual magnetic monopoles instead, then we use the electrical flux quantum e .

²³ Einstein explains gravity by locally eliminating it in the timelike geodesic motion of the origin of coordinates of the free float weightless “LIF” for Local Inertial Frame. The tetrad map is between the LIF class and the LNIF (Local Non Inertial Frame whose origin of coordinate lines in a patch is on a timelike, but not geodesic, world line.)

²⁴ We can do the full Yang-Mills $SU(2) \times SU(3)$ including the weak and strong forces as well as the above $U(1)$ for the electromagnetic force shown here explicitly for simplicity.

$$J(E) = J(0) + \frac{G^* m^2}{\hbar c} = J(0) + \alpha' E^2 \quad (1.17)$$

where

$$J\left(\sim \frac{1}{2} \text{Mev}\right) = \frac{1}{2} \quad (1.18)$$

is the spin of the electron as a Regge pole in the complex angular momentum plane of the scattering amplitude. α' the Regge slope is

$$\alpha' \approx \frac{2}{(1\text{Mev})^2} \quad (1.19)$$

$$J(0) = 0 \quad (1.20)$$

$$\Delta J = 2 \quad (1.21)$$

between Regge poles. Therefore, an exotic lepton of spin 5/2 mass ~ 1.18 Mev predicted. Similarly ones at spin 9/2, 13/2, 17/2... They need not be stable. Tightly bound atomic states with these exotic electrons corresponding to cold fusion and some forms of dark matter? So this half-baked idea is falsifiable.

$$\frac{G^* m^2}{\hbar c} = \frac{G^* m^2 c^4}{\hbar c^5} = \frac{G^* \hbar E^2}{\hbar^2 c^5} = \frac{L_p^{*2}}{(\hbar c)^2} E^2 \quad (1.22)$$

$$\alpha' = \frac{L_p^{*2}}{(\hbar c)^2} = \frac{1}{\hbar c T} \quad (1.23)$$

$$L_p^* \approx \frac{\hbar}{mc} = \frac{G^* m}{c^2} \quad (1.24)$$

$$T = \frac{\hbar c}{L_p^2} \quad (1.25)$$

T is the effective string tension. The length of the string is $\frac{\hbar}{mc}$ but the string looks like a point particle in electromagnetic scattering with a spacelike virtual photon probe because

of enormous space curvature from the strong short range Salam G* field in which the effective size of the electron $\frac{C}{2\pi}$ is

$$\frac{C}{2\pi} = \sqrt{\left[1 - \frac{2L_p^{*2}}{\left(\frac{\hbar}{mc}\right)\left(\frac{p}{\hbar}\right)}\right]} \frac{\hbar}{mc} \quad (1.26)$$

where p is the spacelike 3-momentum transfer from the virtual photon Heisenberg microscope probe.²⁵ The electron looks like a mathematical point when

$$\frac{C}{2\pi} = \sqrt{\left[1 - \frac{2L_p^{*2}}{\left(\frac{\hbar}{mc}\right)\left(\frac{p}{\hbar}\right)}\right]} \frac{\hbar}{mc} = 0 \quad (1.27)$$

i.e.

$$p = \frac{\hbar^2}{2L_p^{*2}mc} \approx \frac{\hbar}{10^{-11}cm} \quad (1.28)$$

at the threshold for the creation of real electron-positron pairs out of the virtual zero point fluctuations of the Dirac spinor electron quantum field. That is, all the lepto-quarks look like point particles in quantum electrodynamic scattering processes as soon as the special relativistic region is reached. This explanatory picture is a major achievement of my theory. David Deutsch in “The Fabric of Reality” rightly laments the current Bohr-inspired attitude not to try to understand the world in detail, but to simply pragmatically calculate numerical predictions without a reality picture.

Finally, a brief review of how Kleinert’s world crystal formalism fits in, i.e. how the “It” of classical spacetime geometrodynamics emerges from the “Bit” of ψ :

$$g_{\mu\nu} = \eta_{\mu\nu} + \frac{1}{2}(\partial_\mu u_\nu + \partial_\nu u_\mu) \quad (1.29)$$

$g_{\mu\nu}$ is the curved spacetime metric rock like “It” field of Einstein’s 1915 geometrodynamics field theory of gravitation. The second term on the RHS of (1.27) is the strain tensor of Kleinert’s world crystal lattice.²⁶

²⁵ Note that (\hbar/mc) is outside the *square root* length strong short range G* gravity contraction factor.

²⁶ I published a paper in 1966-7 in Physics Letters A on ODLRO in “super crystals” e.g. He3.

$$\eta_{\mu\nu} = \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad (1.30)$$

is the flat spacetime metric field of Einstein's 1905 special theory of relativity with the class of Global Inertial Frames (GIF) for a perfect uniform world crystal without any 1-dim topological defects of either curvature disclination or torsion dislocation

$$\Gamma_{\mu\nu}^{\sigma} = \frac{1}{2} g^{\sigma\nu} (\partial_{\mu} g_{\nu\sigma} + \partial_{\nu} g_{\sigma\mu} - \partial_{\sigma} g_{\mu\nu}) \quad (1.31)$$

is the spacetime connection in the curved spacetime for parallel transport of rock like tensor objects ("It") along world lines.

$$D^{\nu} \psi = \partial^{\nu} \psi \quad (1.32)$$

The curved spacetime covariant derivative of a world scalar is same as the ordinary partial derivative.

$$D^{\mu} D^{\nu} \psi = D^{\mu} \partial^{\nu} \psi = (\partial^{\mu} \partial^{\nu} + \Gamma_{\sigma}^{\mu\nu} \partial^{\sigma}) \psi \quad (1.33)$$

Is the curved spacetime D'Alembertian wave propagator operator on the thought like world scalar field ψ ("Bit").

$$R_{\mu\nu\gamma}^{\delta} = \partial_{\nu} \Gamma_{\mu\gamma}^{\delta} - \partial_{\gamma} \Gamma_{\mu\nu}^{\delta} + \Gamma_{\mu\gamma}^{\sigma} \Gamma_{\sigma\nu}^{\delta} - \Gamma_{\mu\nu}^{\sigma} \Gamma_{\sigma\gamma}^{\delta} \quad (1.34)$$

Is the Riemann curvature tensor field of 4th rank for the inhomogeneous "stretch-squeeze" tidal forces seen in the time like geodesic deviation of neighboring two freely floating "test particles".²⁷

$$R_{\mu\nu} = R_{\mu\nu\gamma}^{\gamma} \quad (1.35)$$

Is the Ricci tensor of second rank.

$$R = R_{\mu}^{\mu} \quad (1.36)$$

Is the curvature scalar of zero rank.

²⁷ A "test particle", by definition, has no direct grip back on its rock like geometrodynamical pilot field from which it receives its marching orders. An alleged "flying saucer" cannot be a test particle, but must generate its own timelike geodesic by softening spacetime stiffness. That is, Lp* must be made larger in a boundary layer surrounding the ship. Similarly, ordinary rock like matter and rock like geometry has no direct grip back on its thought like pilot qubit field from which they receive their marching orders.

$$G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} \quad (1.37)$$

Is the Einstein geometrodynamical tensor in eq. (1.7).

Appendix Relation of Blackett and Regge Effects

The Hawking temperature of a Kerr-Newman rotating charged hairless black hole is

$$T = \frac{\kappa\hbar}{2\pi kc} \quad (1.38)$$

The surface gravity is

$$\kappa = \frac{4\pi}{A} [r_+c^2 - Gm] \quad (1.39)$$

$$r_+ = \frac{1}{c^2} \left[Gm + \sqrt{\left(G^2m^2 - \frac{J^2c^2}{m^2} - GQ^2 \right)} \right] \quad (1.40)$$

$$A = \frac{4\pi G}{c^4} \left[2Gm^2 - Q^2 + 2\sqrt{\left(G^2m^4 - J^2c^2 - Gm^2Q^2 \right)} \right] \quad (1.41)$$

Let²⁸

$$G^2m^4 - J^2c^2 - Gm^2Q^2 = 0 \quad (1.42)$$

In this extreme case

$$r_+ \rightarrow \frac{Gm}{c^2} \quad (1.43)$$

$$A \rightarrow \frac{4\pi G}{c^4} [2Gm^2 - Q^2] \quad (1.44)$$

²⁸ This is a Pythagorean equation for a right triangle if you divide each term by c^4 .

Note that the maximal Blackett relation

$$Gm^2 - Q^2 \rightarrow 0 \quad (1.45)$$

For an extreme black hole this implies

$$A \rightarrow \frac{4\pi G}{c^4} [2Gm^2 - Q^2] \rightarrow \frac{4\pi G^2 m^2}{c^4} \quad (1.46)$$

with

$$\kappa \rightarrow \frac{4\pi}{A} [Gm - Gm] \rightarrow 0 \quad (1.47)$$

Hence, the Hawking temperature vanishes

$$T \rightarrow 0 \quad (1.48)$$

Can we have the Blackett effect at finite spin?

$$r_+ = \frac{1}{c^2} \left[Gm + i \frac{Jc}{m} \right] \quad (1.49)$$

No, at least not classically.

Next consider the Schwarzschild limit with zero spin $J \rightarrow 0$ and zero charge $Q \rightarrow 0$.

$$r_+ \rightarrow \frac{1}{c^2} \left[Gm + \sqrt{(G^2 m^2)} \right] = \frac{2Gm}{c^2} \quad (1.50)$$

$$A \rightarrow \frac{4\pi G}{c^4} \left[2Gm^2 + 2\sqrt{(G^2 m^4)} \right] = \frac{16\pi G^2 m^2}{c^4} \quad (1.51)$$

$$\kappa \rightarrow \frac{4\pi}{\frac{16\pi G^2 m^2}{c^4}} [2Gm - Gm] = \frac{c^4}{4Gm} = \frac{c^2}{4L_p^2} \left(\frac{\hbar}{mc} \right) \quad (1.52)$$

$$T \rightarrow \frac{\frac{c^2 \hbar}{4L_p^2} \left(\frac{\hbar}{mc} \right)}{2\pi kc} = \frac{c^2 \hbar^2}{8\pi mc^2 L_p^2 k} \quad (1.53)$$

is the Hawking blackbody radiation temperature.

Let's look at this more closely. We are modeling lepto-quarks as extended vacuum geometrodynamics "Bohm points" in Salam strong short range gravity with $G^* \gg G$ in microscale. Therefore,

$$Q_n = n \frac{e}{3} \quad (1.54)$$

$$n = 0, \pm 1, \pm 2, \pm 3, \dots$$

$$J_{n'} = \frac{n'}{2} \quad (1.55)$$

$$n' = 0, 1, 2, 3, 4, \dots$$

The only continuous variable is m.

$$\frac{GQ_n^2}{G^2 m^2} = \frac{e^2 n^2}{9Gm^2} \equiv 1 - \delta_n \quad (1.56)$$

δ_n is the Blackett deviation parameter. The maximal Blackett effect is when $\delta_n \rightarrow 0$.²⁹

$$G^2 m^2 - GQ_n^2 = GQ_n^2 \delta_n \quad (1.57)$$

$$\sqrt{G^2 m^2 - GQ_n^2 - \frac{J_{n'}^2 c^2}{m^2}} = \sqrt{G^2 m^2 \delta_n - \frac{J_{n'}^2 c^2}{m^2}} = Gm \sqrt{\delta_n - \frac{J_{n'}^2 c^2}{G^2 m^4}} \quad (1.58)$$

The Regge parameter is defined as

$$\eta_{n'} = \frac{J_{n'} c}{Gm^2} \quad (1.59)$$

$$\sqrt{G^2 m^2 - GQ_n^2 - \frac{J_{n'}^2 c^2}{m^2}} = Gm \sqrt{\delta_n - \eta_{n'}^2} \quad (1.60)$$

²⁹ It is understood that G will replace G*.

$$\delta_n - \eta_{n'}^2 \geq 0 \quad (1.61)$$

For an extreme nonradiating black hole at zero Hawking temperature

$$\delta_n - \eta_{n'}^2 = 0 \quad (1.62)$$

$$\delta_n = 1 - \frac{e^2 n^2}{9Gm^2} \quad (1.63)$$

$$\eta_{n'}^2 = \left(\frac{n' \hbar c}{2Gm^2} \right)^2 \quad (1.64)$$

$$1 - \frac{e^2 n^2}{9Gm^2} \geq \left(\frac{n' \hbar c}{2Gm^2} \right)^2 \quad (1.65)$$

An extreme black hole can only obey the maximal Blackett effect if it does not rotate. If it rotates it will be unstable. Stable particles of spin $\frac{1}{2}$ therefore, do not obey the maximal Blackett effect. Indeed no stable particles with spin can obey the maximal Blackett effect. For the extreme black hole, we can get a mass spectrum.

$$\begin{aligned} \left(\frac{n' \hbar c}{2Gm^2} \right)^2 + \frac{e^2 n^2}{9Gm^2} - 1 &= 0 \\ x &= \frac{1}{m^2} \\ a' &= \left(\frac{n' \hbar c}{2G} \right)^2 \\ b' &= \frac{e^2 n^2}{9G} \\ c' &= -1 \end{aligned} \quad (1.66)$$

$$\begin{aligned} x_{\pm}(n, n') &= \frac{1}{2 \left(\frac{n' \hbar c}{2G} \right)^2} \left[- \left(\frac{e^2 n^2}{9G} \right) \pm \sqrt{\left(\frac{e^2 n^2}{9G} \right)^2 + 4 \left(\frac{n' \hbar c}{2G} \right)^2} \right] \\ m(n, n')^2 &= 2 \left(\frac{n' \hbar c}{2G^*} \right)^2 \frac{1}{\left[- \left(\frac{e^2 n^2}{9G^*} \right) \pm \sqrt{\left(\frac{e^2 n^2}{9G^*} \right)^2 + 4 \left(\frac{n' \hbar c}{2G^*} \right)^2} \right]} \end{aligned} \quad (1.67)$$

Note the tachyon solutions.

$$m(n, n') = \sqrt{2} \left(\frac{n' \hbar c}{2G^*} \right) \sqrt{\frac{1}{\left[-\left(\frac{e^2 n^2}{9G^*} \right) \pm \sqrt{\left(\frac{e^2 n^2}{9G^*} \right)^2 + 4 \left(\frac{n' \hbar c}{2G^*} \right)^2} \right]}} \quad (1.68)$$