The Macro-Quantum Vacuum

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Abstract

I conjecture that the Dirac electron vacuum is unstable to the formation of a Bose-Einstein condensate of virtual positronium because of the Coulomb attraction. The phase variation of the resulting center of mass macro-quantum coherent "superfluid" ODLRO complex scalar local order parameter $\Psi(x)$ gives Einstein's classical geometrodynamic LNIF field $g_{\mu\nu}(x)$. The amplitude modulation of this order parameter determines the quintessent local cosmological residual "normal fluid" zero point fluctuation $\Lambda(x)$ field with a unified explanation of repulsive "dark energy" $\Lambda(x) > 0$ and attractive "dark matter" $\Lambda(x) < 0$ as exotic phases of the physical vacuum.

Introduction – unexpected observations of dark energy and dark matter.[2]

"The second problem is the so-called cosmological constant paradox: the vacuum fluctuations predicted by QFT contain a huge Lorentz-invariant energy density, which corresponds in turn to a large cosmological term in the Einstein equations and imply an (unobserved) strong curvature of the universe."[3]

Frank Wilczek wrote[4]:

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[2] "Who ordered that?" I. Rabi on hearing about the neutrino.
[3] "Giovanni Modanese, "Inertial Mass and Vacuum Fluctuations in Quantum Field Theory", hep-th/0009046, 7 Sept. 2000. The attempt by Haisch, Rueda and Puthoff to derive inertial mass from Lorentz force drag through virtual zero point photons fails if only because it does not explain why the cosmological constant generated by the virtual photons is so small.
[4] "Scaling Mount Planck III: Is That All There Is?" p. 11, Physics Today, August, 2002

"Any theory of gravity that fails to explain why our richly structured vacuum, full of symmetry breaking condensates and virtual particles, does not weigh much more than it does is a profoundly incomplete theory."

I think I understand this problem in a unified conservative parsimonious way that is in accord with the experimental data presented in your "Search And Discovery"[5]. According to Bertram Schwarzschild:

"The Boomerang, Maxima, and DASI fits to the CMB power spectrum appeared to confirm an astonishing finding of earlier supernova surveys … namely, that Ω_Λ is about twice as big as Ω_m . In other words, mass plays second fiddle to a "dark" vacuum energy, with the result that the Hubble expansion is actually speeding up in the present epoch. The familiar world is further demeaned by the realization that Ω_b, the cosmic density of ordinary baryonic matter, constitutes only about 15% of Ω_m, the rest being some sort of exotic matter only slightly less mystifying than the dark energy."

The new model

My basic idea here is that the smooth nonrandom coherent symmetry breaking virtual *macro-quantum* vacuum Bose-Einstein condensates *compensate* the *micro-quantum* random incoherent residual virtual particle zero-point vacuum fluctuations of Heisenberg uncertainty noise. The virtual condensates can be pictured as complex numbered coherent signals $\Psi \equiv |\Psi| e^{i \arg \Psi}$ whose phase variations yield Einstein's classical geometrodynamic field $g_{\mu\nu}$ of curved spacetime, and whose amplitude variations damp down the "quintessent" Λ field from the virtual particles forming the Heisenberg uncertainty zero-point random noise.

Virtual bosons have positive random incoherent zero-point energy density with equal negative zero-point pressure.[6] The contribution of the zero-point pressure is three times stronger than the zero-point energy density. Therefore, the net result of virtual off-mass shell zero-point quanta is gravitationally repulsive making a huge unobserved positive contribution to the Λ field of order $L_p^{-2} \sim c^3/hG \sim 10^{66}$ cm^{-2}, the reciprocal Planck area.[7] Therefore a dominance of virtual bosons on the cosmological scale makes the universe accelerate because the "dark energy" vacuum at that scale literally would anti-gravitate. I note Lenny Susskind's conjecture of "UV/IR duality"[8] in which the smallest of scales meets the largest of scales. The problem, as Wilczek alludes to, is that this naïve estimate is about 122 powers of ten too big! This is because the actual net Λ is very close to zero not much more than the reciprocal square of the Hubble radius of 10^{28} cm.

[5] "Observing the Cosmic Microwave Background at High Resolution Bolsters the Inflationary Big Bang Scenario", p. 20, Physics Today, August, 2002

[6] "Cosmological Physics", eqs. (1.85), (1.86) p. 25 & (1.87), (1.88) p. 26, John Peacock, Cambridge, 1999

[7] Each Planck area is worth 1 c-bit of Bekenstein-Hawking gravitational entropy per Boltzmann's constant not from the usual coarse-graining of statistical mechanics. Lenny Susskind conjectures that the number of c-bits in any volume V of 3D space is ~ $V^{2/3}$/Planck Area with The World as a Hologram.

[8] "Twenty Years of Debate With Stephen", hep-th/0204027

Virtual *unbound* [9] fermion-antifermion pairs[10] of the micro-quantum polarized vacuum have the opposite zero-point effect.[11] Therefore, purely random virtual fermion-antifermion pairs with positive dominating zero-point pressure make a negative contribution to Λ on somewhat smaller scales than cosmological corresponding to a gravitating phase of vacuum misnamed the "dark matter"[12] that is ~ 85% of Ω_m according to CBI et-al .

The role of the virtual condensates is to modulate the positive anti-gravitating contributions to the local variable vacuum Λ-field from all the virtual zero-point gauge force bosons and the negative gravitating contributions from all the virtual zero-point gauge source unbound fermion-antifermion pairs. Consider only quantum electrodynamics for simplicity. The fuzzy edge of the Dirac-Fermi surface vacuum of filled negative energy electron states is unstable to the BCS type pair formation[13] from the intrinsic Coulomb attraction between virtual electrons and virtual positrons. Therefore, we expect a Bose-Einstein condensation into a macroscopically occupied virtual bound state with local σ *scale-dependent* complex macro-coherent order parameter $\Psi(x,\sigma)$.[14] Einstein's local geometrodynamic field is[15]

$$g_{\mu\nu}(x,\sigma) = \eta_{\mu\nu} + \frac{L_p^2}{2}\left[D_\mu D_\nu + D_\nu D_\mu\right]\arg\Psi(x,\sigma) \tag{1.1}$$

Where $\eta_{\mu\nu}$ is the globally flat constant spacetime Minkowski metric. The generic internal symmetry gauge force covariant derivatives are[16]

$$D_\mu \equiv \partial_\mu + A_\mu^a(x)T_a \tag{1.2}$$

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9 Virtual ionized neutral plasma.

10 Zero-point vacuum polarization

11 "The Quantum Vacuum", 10.6 eqs. (10.105) (10.106) pp 353-354, Peter W. Milonni, Academic Press, 1994

12 Schwarzschild calls this $\Lambda < 0$ vacuum phase "exotic matter", but that should not be confused with the $\Lambda > 0$ "exotic matter" (AKA "dark energy") Kip Thorne needs to make a traversable wormhole.

13 We do not need the electron-phonon interaction here as in a real superconductor with real electron-electron pairs. The Fermi momentum is ~ h/L_p. The binding energy of the virtual pair is ~ $\alpha m_p c^2$ ~ -10^{17}Gev ~ critical temperature to destroy vacuum superconductivity. The condensation energy density is ~ -$L_p^{-3}(m_e/m_p)\alpha m_p c^2$ ~ -$L_p^{-3}\alpha m_e c^2$~ 10^{99} 10^{-2} Mev/cc. The photon rest mass is ~ 10^{-65} gm with a Meissner penetration depth ~ 10^{28} cm, so that the ratio of penetration depth to coherence length of the macro-quantum vacuum >> 1, i.e. a hard superconductors with magnetic vortex string topological defects.

14 "A Career in Theoretical Physics", P.W. Anderson, 1994 "More is Different", "Coherent Matter Field Phenomena in Superfluids", "Macroscopic Coherence and Superfluidity", "Hard Superconductor" et-al. This is an adaptive windowed wavelet generalization of the rigid windowed Fourier transform based Wigner phase space density with ODLRO. The scale σ replaces the momentum p. We have scale space rather than phase space. This is more appropriate for curved spacetime where global translational symmetry is broken.

15 This is Wheeler's "IT FROM BIT", i.e. GEOMETRY from INFORMATION.

16 T.W.B. Kibble, "Lorentz Invariance and the Gravitational Field", J. Math. Phys, 2, 212, March-April, 1961.

For a Lie group G with locally variable infinitesimal parameters $\varepsilon^a(x)$

$$\delta\Psi(x) \approx \varepsilon^a(x) T_a \Psi(x) \tag{1.3}$$

The Lie algebra is

$$[T_a, T_b] = f_a{}^c{}_b T_c \tag{1.4}$$

With compensating spin 1 gauge force field "potentials" $A^a_\mu(x)$ that are connections for parallel transport in the extra internal dimensions of fiber space. When G = U(1) we have electromagnetism for the off mass shell virtual positrons and electrons in the Dirac vacuum. We are not interested here in exciting real on mass shell electron-positron pairs. The T in this case will be ~ (2e/hc) because the induced 3-current of a virtual positron adds in the same direction as that of the virtual electron. The virtual PV 4-current is spacelike. Therefore, the vacuum charge density does not vanish in all Lorentz frames. This may explain anomalous experimental data reported by Bo Lehnert?[17]

Einstein's Equivalence Principle

Einstein's equivalence principle (EEP) formally corresponds to the *local* tetrad transformation at point event P

$$g_{\mu\nu}(LNIF(P)) = e^a_\mu(P) e^b_\nu(P) \eta_{ab}(LIF) \tag{1.5}$$

Kibble, predating Gennady Shipov's work[18], derived the 16 tetrad (vierbein) components $e^a_\mu(P)$ by locally gauging the 4-parameter translation subgroup of the Poincare group of globally flat spacetime. Doing this results in Diff(4) general coordinate transformations in curved spacetime as emerging from spin 2 tensor gauge transformations on globally flat space time when the flat action is made gauge invariant. In addition, if the 6-parameter Lorentz subgroup of the Poincare group is also locally gauged, Kibble[19] (in 1961) got 4-rotations of the vierbein frames under parallel transport as the inhomogeneous non-symmetric connection field

$$A^\lambda_{\mu\nu}(P) = \Gamma^\lambda_{\mu\nu}(P) + C^\lambda_{\mu\nu}(P) \tag{1.6}$$

[17] Vigier Conference at UCB, Summer 2000 published by Kluwer.
[18] "A Theory of Physical Vacuum", Moscow, 1998, ISBN 5-7273-0011-8
[19] Kibble derives mixed compensating field some in tangent fiber space and some in base space, but one simply uses the tetrads to change from one to the other locally at fixed P. The connection field is used to move any tensor object along a path from P to P' in a generally non-integrable (anholonomic) path-dependent way.

splitting into symmetric and antisymmetric parts in the lower μ,ν curved base spacetime indices that correspond to disclination and dislocation topological line defects respectively in Hagen Kleinert' elastic 4-World Crystal Lattice interpretation of Einstein's general relativity http://www.physik.fu-berlin.de/~kleinert/kleiner_reb1/contents2.html . The anti-symmetric torsion $C^{\lambda}_{\mu\nu}$ was not in Einstein's 1916 theory, but he did have it in one of his versions of his unified field theory. The tetrads and the connection are treated as independent fields. Einstein's more special 1916 theory connects them without torsion. Kibble notes that torsion vanishes in the vacuum, but that is classical without the quintessent Λ field. I am not, as yet, able to formally duplicate Kibble's local gauging of the entire Poincare group within my new paradigm.[20] However, the EEP appears formally trivial in my new picture. That is, there is a U(1) gauge transformation with scale-dependent local phase χ

$$\chi : g_{\mu\nu}\left(LNIF(P)\right) \to \eta_{\mu\nu} \tag{1.7}$$

such that

$$\left[D_\mu D_\nu + D_\nu D_\mu\right]\left(\arg\Psi(x,\sigma) + \chi(x,\sigma)\right) = 0 \tag{1.8}$$

The second term on the RHS of (1.1) need not be small. This is not a linear perturbation theory. I extend Einstein's local field equation to

$$G_{\mu\nu}(x,\sigma) + \Lambda(x,\sigma) g_{\mu\nu}(x,\sigma) = -8\pi\frac{G}{c^4}T_{\mu\nu}(x,\sigma) \tag{1.9}$$

With the covariant Landau-Ginzburg equation[21]

$$D^\mu D_\mu \Psi(x,\sigma) + \alpha\Psi(x,\sigma) + \beta\left|\Psi(x,\sigma)\right|^2 \Psi(x,\sigma) = 0 \tag{1.10}$$

"More is Different" broken "Goldstone" symmetry needs $\alpha < 0$, $\beta > 0$. I introduce a "wavelet transform" scale parameter σ[22]. Furthermore, this virtual "two fluid" model of the vacuum has

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[20] I mean how to express the tetrads and connection directly in terms of the PV coherence $\Psi(P)$.

[21] "Hard Superconductors" P.W. Anderson. This is "BIT FROM IT", i.e. INFORMATION from GEOMETRY illustrating no action without reaction like in Escher's "Drawing Hands". This extra detail is not in Wheeler's writings as far as I know.

[22] A Friendly Guide to Wavelets", Gerald Kaiser, Birkhauser, 1994. The wavelet transform with adaptive window scale σ is more suited to variably curved spacetime where the rigid Fourier transform definition of the Wigner phase space density breaks down. The macro-quantum order parameter $\Psi(x,\sigma)$ is related to a Wigner scale space density generalization of the Wigner phase space density. "Phase Space Picture of Quantum Mechanics", Y.S. Kim, M.E. Noz, World Scientific, 1991

$$\Lambda(x,\sigma) = \frac{1}{L_p^2}\left[1 - L_p^3\left|\Psi(x,\sigma)\right|^2\right] \quad (1.11)$$

Λ(x,σ)	Vacuum Phase
+	Dark Energy
0	Einstein Vacuum
-	Dark Matter

Conservation of "momenergy"[23] generalizes to

$$G_{\mu\nu}{}^{;\nu} + g^{\nu\lambda} D_\lambda \Lambda g_{\mu\nu} = -8\pi \frac{G}{c^4} T_{\mu\nu}{}^{;\nu} \quad (1.12)$$

where the semi-colon is the usual Diff(4) spacetime covariant derivative. Notice however, that I suggest using a gauge covariant derivative in the new zero point quintessent Λ field term giving a direct invariant coupling of it to the gauge force potential. The question arises whether one should use a generalized space-time + gauge covariant derivative. For example on a contravariant "spin 1" first rank world tensor B^μ

$$\hat{D}_\nu B^\mu \equiv D_\nu B^\mu + \Gamma^\mu_{\lambda\nu} B^\lambda \quad (1.13)$$

Thus, the generalized covariant divergence of the Einstein tensor would be

$$\hat{D}_\nu G^{\mu\nu} = D_\nu G^{\mu\nu} - \Gamma^\mu_{\lambda\nu} G^{\lambda\nu} - \Gamma^\nu_{\lambda\nu} G^{\mu\lambda} \quad (1.14)$$

With this Ansatz,[24] much stronger than (1.8), the generalized covariant divergence of macro-quantum local Einstein field equation would be

$$\hat{D}_\nu G^{\mu\nu} + \hat{D}_\nu\left(\Lambda g^{\mu\nu}\right) = -\frac{8\pi G}{c^4} \hat{D}_\nu T^{\mu\nu} \quad (1.15)$$

I am merely mentioning this possibility of using gauge covariant derivatives in computing the divergence of Einstein's field equation. This is not actually done in standard GR because vacuum polarization is thought to be much too tiny to matter. Doing so, however, would bypass the spacetime stiffness factor G/c^4.

[23] "A Journey into Gravity and Spacetime", Ch 6, John Archibald Wheeler, Scientific American, 1990

[24] Normally this is not done because the vacuum is so hard to polarize inQED and spacetime is very stiff. The size of the response of geometry $\delta g_{\mu\nu}$ to the EM vector potential at scale L would be ~ $\sqrt{\alpha}\, L_p^2/L^2$.

My new virtual superfluid vacuum theory of the variable quintessent $\Lambda(x,\sigma)$ field explaining both "dark energy" and "dark matter" as positive and negative values, respectively, of the same field at different scales σ may be equivalent to a torsion field theory.[25] I make the half-baked *conjecture* that

$$g^{\nu\lambda}\partial_{\lambda}\Lambda \stackrel{?}{=} \mathrm{T}^{\nu\lambda}_{\lambda} \tag{1.16}$$

Where $T^{\nu\lambda}_{\mu} = -T^{\lambda\nu}_{\mu}$ is the 3rd rank Shipov "contortion tensor".

The usual Bianchi identities corollary result

$$G^{\mu\nu}_{;\nu} = 0 \tag{1.17}$$

only works when the manifold has zero torsion, metricity and constant uniform Λ.[26]

The general relativity Einstein-Hilbert field Lagrangian for curvature scalar R coupled to a spin zero complex scalar field is

$$L = \frac{c^4}{G}\int R\sqrt{g}d^3x + \int\sqrt{g}\left[g^{\mu\nu}(\hbar c)^2\partial_{\mu}\varphi^*\partial_{\nu}\varphi - m^2c^4\varphi^*\varphi + \beta(\varphi^*\varphi)^2\right]d^3x \tag{1.18}$$

Where the physical dimensions of the spin 0 field are:

$$[\varphi] = \frac{1}{\sqrt{EL^3}} \tag{1.19}$$

Note that

$$g \equiv \det g_{\mu\nu} \tag{1.20}$$

Since the macro-quantum vacuum is superfluid, as in the two fluid model with ODLRO, the virtual BEC second quantized spin 0 field operator is[27]

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[25] "A Theory of Physical Vacuum", Gennady Shipov, Moscow, 1998 (ISBN 5-7273-0011-8)

[26] Wheeler and Ciufolini, "Gravitation and Inertia". See also Hagen Kleinert "Gauge Fields in Condensed Matter, Vol II Stresses and Defects" in which curvature and torsion are infra-red disclination and dislocation topological defects in the Planck-scale 4-D "world crystal lattice". I relate this to phase singularities in eq. 1.1, which generalizes the deBroglie-Bohm pilot wave guidance constraint from quantum fluid flow to quantum relativistic crystal elasticity. Eq 1.1 can be made gauge invariant in the usual minimal coupling way as in the micro-quantum Bohm-Aharonov effect and the macro-quantum Josephson effect.

[27] The "normal fluid" fluctuations are the zero point vacuum fluctuations of the spin 0 field that maintain the generalized phase rigidity or long range macro-quantum phase coherence upon which the metastability of the physical vacuum we live in depends.

$$\hat{\varphi}(x) = \langle \varphi(x) \rangle + \hat{\varphi}_{zpf}(x) \tag{1.21}$$

$$\langle \varphi(x) \rangle \equiv \frac{\Psi(x)}{\sqrt{m_p c^2}} \tag{1.22}$$

The second quantized "normal fluid" operator $\hat{\varphi}$ destroys an unbound virtual electron-positron pair in the random plasma near the fuzzy Heisenberg edge of width ~ $2m_ec$ of the Dirac-Fermi sphere of radius h/L_p of the micro-quantum electron vacuum and adds a bound virtual positronium to the Bose-Einstein condensate. The Hermitian conjugate $\hat{\varphi}$ ionizes a virtual pair out of the coherent condensate into the random noisy plasma but still inside the two-fluid vacuum of course. The effective boson is the center of mass motion of the virtual electron-hole (positron) pairs. The relative motion is integrated out.

The effective Landau-Ginzburg Bose-Einstein condensate potential energy *density* with spontaneous broken vacuum symmetry is[28]

$$V_{eff} = -m^2c^4\varphi^*\varphi + \beta(\varphi^*\varphi)^2 \tag{1.23}$$

$$\begin{aligned} &\frac{\delta V_{eff}}{\delta \varphi^*} = -m^2c^4\langle\varphi\rangle + 2\beta\langle\varphi\rangle^*\langle\varphi\rangle^2 = 0 \\ &\langle\varphi\rangle \neq 0 \\ &|\langle\varphi\rangle|^2 = \frac{m^2c^4}{2\beta} \end{aligned} \tag{1.24}$$

$$V_{eff\,\min} = -\frac{(m^2c^4)^2}{2\beta} + \frac{(m^2c^4)^2}{4\beta} = -\frac{(m^2c^4)^2}{4\beta} \tag{1.25}$$

This condensate term adds an attractive "dark matter" contribution to R in the Hilbert gravity Lagrangian in the form of a variable cosmological field i.e. R – 2Λ where

$$\Lambda_{bec}(x) = \frac{G}{c^4}V_{eff\,\min}(x) = -\frac{G}{c^4}\frac{(m^2c^4)^2}{4\beta(x)} = -\frac{G}{c^4}(mc^2)^2|\langle\varphi(x)\rangle|^2 = -Gm_p{}^2|\langle\varphi(x)\rangle|^2 \tag{1.26}$$

That is, the Lagrangian is now

[28] In lowest order approximation ignoring spacetime gradients in the coherent PV order of the virtual electron-positron pairs.

$$L = \frac{c^4}{G}\int \left(R - 2\Lambda_{bec}\right)\sqrt{g}\,d^3x + \int \sqrt{g}\begin{bmatrix} g^{\mu\nu}\left(\hbar c\right)^2 \partial_\mu\left(\langle\varphi\rangle + \hat{\varphi}\right)^* \partial_\nu\left(\langle\varphi\rangle + \hat{\varphi}\right) \\ -m^2c^4\left[\langle\varphi^*\rangle\hat{\varphi} + \langle\varphi\rangle\hat{\varphi}^* + \hat{\varphi}\hat{\varphi}^*\right] + \beta\left(....\right)^2 \end{bmatrix} d^3x \quad (1.27)$$

The second part of the RHS of (1.15) has the graviton-condensate-virtual electron-positron plasma interactions.

The random zero point noise of the effective virtual bosons adds a positive antigravitating "dark energy" contribution of order L_p^{-2} to the cosmological field as do the virtual zero point spin 1 photons. The net result is

$$\begin{aligned} &\Lambda_{eff} = \Lambda_{zpf} - \Lambda_{bec} \approx \frac{\varsigma}{L_p^2} - -Gm_p^{\ 2}\left|\langle\varphi(x)\rangle\right|^2 \\ &Gm_p^{\ 2} = \hbar c \end{aligned} \quad (1.28)$$

This research has been supported separately by Roger Coolidge and Joseph Firmage, the latter as part of ISSO 1999-2000 R&D in which Vladimir Poponin arranged for Gennady Shipov to come from Moscow for several visits including ISSO funding of J. P. Vigier's 80th Birthday at the Faculty Club of the University of California in Berkeley http://www.wkap.nl/prod/b/1-4020-0885-6 . ISSO[29] Director, Creon Levit, also of NASA Ames and Todd Desatio has assisted in this research with helpful comments and typo error corrections.

Enigmatic Dark Matter and Dark Energy Observations

"dark matter alone is not abundant enough to halt the observed universal expansion. More surprising still is the suggestion that the dominant energy in the universe may be associated with empty space, and moreover, that this energy is causing the expansion of the universe to accelerate with time. Exotic dark matter dominating the mass of the universe is a concept that may be hard for some to accept. But at least dark matter is 'stuff', however exotic. How much harder is it to get used to the idea that most of the energy density of the universe may literally be associated with nothing at all." Preface to "Quintessence" by Lawrence Krauss (Basic Books, 2000)

I have news for Professor Krauss. Both gravitating dark matter and the anti-gravitation dark energy accelerating the universe's expansion are simply negative and positive regions respectively of a single unified real L field. This L field is the residual random zero point energy fluctuation (zpf) contribution to the macro-quantum vacuum curvature term in Einstein's extended local geometrodynamic field equation for the bending of spacetime by the stress-energy density of both real matter-radiation outside the vacuum

[29] International Space Sciences Organization 1999 – 2000 now defunct with Dot.Com crash.

and virtual “zero-point” matter-radiation inside the vacuum.

“the [zero-point] energy associated with the vacuum has precisely the form that results in a cosmological constant of the type Einstein invented ad hoc in 1916 ... We now have to ask not why the energy of empty space might be nonzero, but rather why it isn’t much larger than is allowed by current observations... Somehow we have to explain how the cosmological constant could be at least 129 orders of magnitude smaller than we would naively estimate it should be. To date, no one has the slightest clue how this could result.” Krauss, p. 104-5

Krauss’s last sentence was true when written ~ 2000, but it is not true today 2002 because I have the explanation in this book.

Synopsis: The micro-quantum vacuum of special relativistic Schwinger source theory with zero expectation value (G/c4)<tuv(zpf)> = Lgmn is unstable against the formation of a macro-quantum Bose-Einstein condensation of a huge number of virtual electron-positron pairs at the fuzzy Heisenberg uncertainty edge of the Fermi-Dirac sphere into the same single particle bound state wave form for the phase-locked motion of the center of mass of each pair. The result is a holographic coherent phase order suppressing the random micro-quantum vacuum zero point fluctuations of all the quantum fields. This emergent “more is different” macro-quantum coherence gives Einstein’s geometrodynamics with the new quintessent locally variable L field term.

Cal Tech’s Fritz Zwicky at Mount Wilson in 1933 first inferred non-radiating gravitating dark matter in the fast relative motion within a group of galaxies ten million light years from us.

“There is now overwhelming evidence that more than 90% of the entire mass within the visible universe is made of material that is invisible to telescopes. The gravitational pull of this ‘dark matter’ therefore determines the motion of stars in galaxies, of galaxies in clusters of galaxies, and indeed of the universe itself.” Krauss

The dark matter is not made of the same visible star stuff we are, i.e. protons, neutrons and electrons. The dark matter in and around the galaxies is ten times the visible galactic matter that is the same star stuff we are and it reaches ten times as far as the visible star stuff. Even that galactic dark matter is only one tenth of all the gravitating dark matter that is one hundred times more than all the star stuff we are.

I predict that the experiments to detect dark matter in the lab in the form of exotic particles will all fail! This is like the Michelson-Morley experiment to detect the motion of the Earth through the aether that also failed. If I am wrong about this, then my L theory is falsified in the sense of Karl Popper’s criterion.

1. “the worst fine tuning problem in physics ... [is] the cosmological constant. If [it] is nonzero, but small, then a fine tuning of about 125 decimal places seems called for ... To date, no one even understands how to address the cosmological constant problem.” p.

142, Krauss

2. "Thus, whether dark matter or dark energy provides merely 90% of the mass in the universe today, as virial estimates indicate, or 99%, as the flatness argument suggests, there is now overwhelming reason to believe that all, or most dark matter is made from something else." p. 168 Krauss

Gravity and Electrodynamic Vacuum Polarization

For electron plasma[30] in global flat spacetime, the important EM field equation for off mass shell virtual photons of the non-radiating near induction field is

$$p^2 \tilde{A}_a = \left(c^2 \vec{k}^2 - \omega^2\right) \tilde{A}_a\left(\vec{k},\omega\right) = 4\pi \tilde{j}_a\left(\vec{k},\omega\right) \tag{2.1}$$

For a virtual photon of any polarization

$$c\left|\vec{k}\right| \neq \omega \tag{2.2}$$

The response of the plasma to an EM field is

$$\tilde{j}_a\left(\vec{k},\omega\right) = -\tilde{K}_a^b\left(\vec{k},\omega\right)\tilde{A}_b\left(\vec{k},\omega\right) \tag{2.3}$$

Gauge invariance implies

$$\tilde{K}_a^b\left(\vec{k},\omega\right) \approx p^b p_a - \eta_a^b p^2 \tag{2.4}$$

Impose the Lorentz gauge constraint

$$p^a \tilde{A}_a\left(\vec{k},\omega\right) = 0 \tag{2.5}$$

to get

$$\tilde{K}_a^b\left(\vec{k},\omega\right) = -\eta_a^b \tilde{K}\left(\vec{k},\omega\right) \tag{2.6}$$

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[30] P. W. Anderson "Plasmons, Gauge Invariance and Mass", Phys. Rev. 130, April 1963, p. 439 The Dirac vacuum is a virtual electron-positron plasma. The spin 1/2 electrons and positrons are off mass shell just like the spin 1 photons.

If the plasma electron number density is ρ_e, in the light cone limit of real far field photons at the pole of the single photon propagator with zero self-energy

$$\underset{p\to 0}{Lim}\,\tilde{K}\left(\vec{k},\omega\right)=\frac{\rho_e e^2}{mc}\equiv K^* \qquad (2.7)$$

For the Dirac vacuum

$$\tilde{j}_a\left(\vec{k},\omega\right)=-\alpha\left(\vec{k},\omega\right)p^2\tilde{A}_a\left(\vec{k},\omega\right) \qquad (2.8)$$

Insert a real electron probe particle on the Dirac vacuum. Therefore, there is an external electromagnetic field of this probe plus the internal zero point vacuum field. Thus,

$$\tilde{j}_a\left(\vec{k},\omega\right)=-\tilde{K}\left(\vec{k},\omega\right)\left[\tilde{A}_a^{\text{int}}\left(\vec{k},\omega\right)+\tilde{A}_a^{ext}\left(\vec{k},\omega\right)\right] \qquad (2.9)$$

$$\tilde{A}_a^{\text{int}}\left(\vec{k},\omega\right)=\frac{+4\pi\tilde{j}_a\left(\vec{k},\omega\right)}{p^2} \qquad (2.10)$$

The total EM potential distorted by the real charged probe is, therefore,

$$\tilde{A}_a\left(\vec{k},\omega\right)=\left[\frac{p^2}{p^2+4\pi K\left(\vec{k},\omega\right)}\right]\tilde{A}_a^{ext}\left(\vec{k},\omega\right) \qquad (2.11)$$

This equation includes both non-radiating near induction fields of virtual photons off the light cone[31] and radiating far fields of real photons on the invariant light cone (mass shell).

For real photons propagating energy, there is a low frequency cutoff at the plasma frequency where

$$(m_\gamma c)^2=-p^2=4\pi\tilde{K}\left(\vec{k},\omega\right)\equiv\left(\frac{\hbar\omega_p}{c}\right)^2\approx\frac{4\pi\rho_e e^2}{m_e} \qquad (2.12)$$

So that

$$\omega^2\approx\omega_p^2+c^2\vec{k}^2 \qquad (2.13)$$

[31] Both inside timelike slower than light and outside spacelike faster than light.

J. P. Vigier suggests that the photon vacuum rest mass corresponds to the cosmological Hubble radius of ~ 14 billion light years or 10^{-65} grams. This model does not have any macro-quantum vacuum coherence like the actual model I propose.

What about gravity? I mean what about the geometrodynamic response to an electromagnetic 4-potential? In my model the $g_{\mu\nu}\left(LNIF\right)$ geometrodynamics is from the phase modulation of the spin ½ vacuum coherence and the quintessent field Λ is from the amplitude modulation.

To be continued.