WHAT IS THE UNIVERSE MADE OF?

The emergence of gravity and dark energy/matter from the cohering of zero point energy.

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Abstract

Ordinary matter made from real on-mass-shell lepto-quark fermions and gauge force bosons only accounts for approximately 4% of all the large-scale stuff of our universe, which may be one of a infinity of parallel universes in hyperspace that we call "Super Cosmos." I propose that the remaining 96% of our universe consists of two forms of partially coherent exotic vacuum dominated by a condensate of bound virtual electron-positron pairs. Einstein's gravity emerges from the variations in the macro-quantum coherent phase field of the condensate. This condensate is the inflation field in the large-scale cosmological limit. Both dark energy and dark matter are simply residual total zero point energy densities that emerge from the vacuum condensate's intensity variations. Approximately 73% is anti-gravitating zero point "dark energy" density with equal and opposite negative pressure that is causing our universe to accelerate in its expansion rate. The remaining gravitating 23%, called "dark matter," is also zero point energy density with equal and opposite positive pressure found concentrated in large-scale structures like the galactic halo that prevents our solar system from escaping into inter-galactic space. Astrophysical scale geon structures of w = -1 dark matter simulate w = 0 CDM in terms of their gravity lensing. Therefore, dark matter detectors can never click with the right stuff to explain $\Omega_{CDM} \sim 0.23$ only with false positives. Supersymmetry partners whizzing through space cannot explain the dark matter in this theory, nor should gravity be quantized in the usual way. The electron, as a Bohm "hidden variable" on the micro-scale for example, is a spatially-extended structure whose self-electric charge repulsion, Casimir force and repulsive spin rotation are balanced by the strong short-range zero point energy induced gravity from its exotic vacuum core. The electron, and the quarks, shrink in size, up to a certain minimum, when hit with large momentum scattering transfers from strong space warping that makes their surface areas small compared to what they would be in flat space for a given radial distance. I refer to experimental work by Ken Shoulders on "exotic vacuum objects" or "EVO" charged geons made from large numbers of electrons glued together by zero point energy is included. The zero point force holding as many as one hundred billion electrons together is not the QED Casimir force, which may even be repulsive, but is the strong short-range gravity force induced by the zero point energy by the entirely different process of Einstein's general relativity omitted from the flat space-time QED calculations. These EVOs show anomalous motions and energies that seem to be examples of Alcubierre's "warp drive" and "cold fusion" respectively. The direct gravitational effect of zero point energy should not be confused with the quantum electrodynamical Casimir force which is also a negative power law and may be repulsive depending on the shape of the EVO charge distribution. Indeed, the direct gravity effect will need to counter-act the Casimir force in such a case. The general idea is that zero point energy manifests in two qualitatively different ways using different equations of physics one from general relativity, the other from quantum electrodynamics. Previous theorists in this subject have not been aware of this important distinction.

Precision Cosmology

Starting in 1998, still emerging cosmological data, with a hitherto unprecedented current precision of ~ 2%, has shown that distant type Ia supernovae appear dimmer than is predicted from their redshifts in a universe whose expansion is slowing down.

"The supernova data--bolstered by an imposing variety of other, less direct evidence--have led to an evolving consensus called the concordance model: It asserts that the cosmos is currently in an epoch of

accelerating expansion driven by a pervasive dark vacuum energy dense enough to overcome the gravitational braking of all the mass in the universe. The model is agnostic about the nature of the dominating vacuum energy, so long as its pressure is sufficiently negative. Somewhat counter-intuitively, general relativity asserts that negative pressure would act as a repulsive counterpoise to gravity on the cosmological scale. The energy of ordinary electromagnetic radiation won't do; its pressure is positive. The dark energy might be manifesting the optional cosmological constant allowed by the field equations of general relativity. But the magnitude of inferred from the observations is implausibly small by many orders of magnitude. Alternatively, the dark energy might be more dynamical, its density varying in time and space as imagined in a number of "quintessence" theories. In any case, a cosmology dominated by vacuum energy of unknown character has profound implications for fundamental physics. So supernova observers have been at great pains to seek out, or eliminate, more prosaic astrophysical explanations for the anomalous faintness of high-redshift supernovae--for example, obscuring dust or possible evolutionary differences between recent supernovae and those of earlier epochs." [i]

Indeed, in my opinion, the preponderance of the new data in the past six years rules out previously plausible "tired light" and other alternative cosmological scenarios to the standard big bang model with inflation.

Ordinary matter consisting of plasma, atoms and radiation, magneto-hydrodynamic fields, cosmic rays etc is only approximately 4% of all the "stuff" in the universe that can be detected indirectly via its gravity or anti-gravity effects on sources emitting radiation. The density of atoms and plasma decreases as the universe expands as

$$R(z)^{-3} = (1+z)^{3} \tag{1.1}$$

for a given cosmological redshift z. Equation (1.1) is a special case of the more general equation

$$R(z)^{-3(1+w)} = (1+z)^{3(1+w)} \tag{1.2}$$

Where, in the usual ideal cosmological ideal fluid model of isotropy for the equation of state of sources in Einstein's field equation

$$w \equiv \frac{pressure}{energy\_density} \equiv \frac{p}{\rho c^{2}} \tag{1.3}$$

Source	w
Atoms, plasma, protons, electrons…	~ 0 when v << c
Radiation	+1/3
Zero point vacuum fluctuations	-1
Quintessence	-1 < w < -1/3
Phantom energy with "BIG RIP" destroying the universe.	w < -1

Note that for phantom energy, the effective density increases as the universe expands. If the phantom energy density is positive, the anti-gravitating negative pressure of the phantom energy rips the universe apart in our future. This does not happen with zero point energy. Einstein's field equation in the weak curvature limit appropriate for the aging universe has the Newtonian Poisson equation limit

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi T_{\mu\nu} \rightarrow \nabla^2 V(w) = 4\pi G\rho(1+3w) \tag{1.4}$$

For the special case of radiation we get the famous factor of 2 for the bending of light by gravity predicted by Einstein and first observed, though with large errors, by Eddington in 1919. Newton's theory of gravity only allows w = 0. The w dependence is one of Einstein's 1916 corrections to Newton's 17th Century theory of gravity.

Vacuum Coherence

Without getting too complicated about the mathematics of the analyticity and pole structure with boundary condition contours for the Green's function "propagators" in the complex energy plane for globally flat space-time without gravity. We can simply say that real particles obey a "mass shell" constraint or "dispersion equation" relating the energy to the momentum. [ii]

$$\begin{aligned} E &= E(p) \\ \omega &= \omega(k) \end{aligned} \tag{2.1}$$

Virtual particles do not obey this constraint. Their particle energy or wave frequency has no relation to their particle momentum or wave number. In terms of Heisenberg's uncertainty principle, real particles obey, neglecting factors of 2 and π.

$$\begin{aligned} \Delta E \Delta t &\geq \hbar \\ \Delta p \Delta x &\geq \hbar \end{aligned} \tag{2.2}$$

In contrast, virtual particles obey

$$\begin{aligned} \Delta E \Delta t &\leq \hbar \\ \Delta p \Delta x &\leq \hbar \end{aligned} \tag{2.3}$$

Let us review the basic idea of the BCS theory of superconductors. The mobile electrons in a metal obey the Paul exclusion principle that not more than one fermion can occupy the same quantum state. The ground state of the metal is filled up to a Fermi level that has positive energy because the electrons are "real poles of the propagator" in the sense of quantum field theory. Electrons repel each other. However these electrons are in the periodic potential of a crystal and under certain conditions the virtual quanta of crystal vibrations called virtual phonons can overcome the electrical repulsion from virtual photon exchange between two real electrons that fall into a bound state with a lower energy than the two electrons normally have. This electron pair bound state acts like a boson and a large number N_0 of electron pairs fall into this same bound state whose quantum wave function $\psi(x)$ in the center of mass coordinates of the pair is the shape of the coherent order parameter $\Psi(x)$ [iii]

$$\Psi(x) = \sqrt{N_o}\,\psi(x) \tag{2.4}$$

This macro-quantum order parameter or giant quantum wave function $\Psi(x)$ does not obey the same rule as does the microscopic wave function $\psi(x)$. $\Psi(x)$ is local, but it has robust long-range phase coherence unlike the fragile micro-quantum phases. $\Psi(x)$ has phase rigidity and, therefore, does not collapse like $\psi(x)$ does into some eigenfunction φ^j with real number eigenvalue j of a measurement observable corresponding to Bohr's nonlocal "total experimental arrangement" according to the Born probability/von Neumann projection rule for sub-quantal heat death with signal locality given by

$$\psi = \sum_j c_j \varphi^j$$
$$p(j) = \left|c_j\right|^2 \qquad (2.5)$$
$$\sum_j p(j) = 1$$

for identically prepared ensembles of micro-quantum systems. There is no actual statistical ensemble in this macro-quantum situation. The physical conditions for the micro-quantum measurement theory of von Neumann simply are not met in macro-quantum situations. Indeed, our macroscopic smooth space-time as described in Einstein's 1916 general theory of relativity is not "classical" but is, rather, a smooth macro-quantum vacuum coherence phase modulation in what we might call a "world hologram." Roger Penrose has noted serious problems in the usual notion of the "classical limit" in his popular books "The Emperor's New Mind" and "Shadows of the Mind." Indeed, the emergence of smooth curved space-time with gravity works like this. Imagine a globally flat completely incoherent random zero point fluctuating false vacuum described by quantum field theory. Consider a toy model with only U(1) quantum electrodynamics neglecting the weak and strong local gauge invariant compensating field forces from the SU(2) and SU(3) internal symmetry groups respectively. There are no real particles allowed in this false vacuum because you cannot have rest mass inertia of a real electron without gravity. That would be a violation of the equivalence principle of gravity and inertia. The organizing idea here is strong local gauge invariance, which is the hypothesis that every continuous symmetry group, both space-time and internal must be locally gauged to get a compensating gauge force dynamical field. All rest masses m in the globally flat pre-inflationary false vacuum are zero because there is no gravity as yet and therefore no actual ordinary matter. The relevant space-time symmetry group is at least the 15-parameter conformal group that splits into several pieces.

Sub Group	Infinitesimal Generators	Compensating Field
4 space-time translations	Total Momentum-Energy	Einstein's Gravity
6 space-time rotations	Angular Momentum & Boosts	Torsion
4 special conformal boosts to constant local acceleration hyperbolic "relativistic rocket" motion	?	?
Dilation	?	?

Compare to the internal symmetry groups

U(1) Electromagnetic	1 Electric Charge	A_μ Vector Potential
SU(2) Weak Radioactivity	3 Weak "Flavor" Charges	$A_\mu{}^a$ Vector Potential
SU(2) Strong Sub-Nuclear	8 Strong "Color" Charges	$A_\mu{}^b$ Vector Potential

There is also a discrete broken mirror or "parity" symmetry in the SU(2). For now we ignore the Higgs mechanism for the emergence of lepto-quark rest masses m ~ 1 Mev from vacuum coherence in the SU(2) that for consistency cannot happen in the pre-inflationary false vacuum without the more general vacuum coherence. It all must happen in a globally self-consistent way. There can be no real particles in the pre-inflationary globally flat completely incoherent random false vacuum without emergent gravity-inertia. Recall the basic "IT FROM BIT" (John Archibald Wheeler's phrase) relation in David Bohm's pilot wave hidden variable theory of non-relativistic particle micro-quantum theory. The particle-hidden variable with velocity $\vec{v}$ and inertia m is the material "IT" whilst the thought-like pilot wave ψ of non-classical "qubit" information is "BIT" with the two related by the guidance constraint

$$\vec{v}(\vec{r},t) = \frac{\hbar}{m}\vec{\nabla}\arg\psi(\vec{r},t) \tag{2.6}$$

In analogy with (2.6) for a 3D micro-quantum fluid I make the Ansatz for a 4D macro-quantum elastic covariant "aether" that is the long wave limit of Hagen Kleinert's "World Crystal Planck Lattice" at event P for the infinitesimal distortion or "warp field" whose strain tensor is Einstein's curved space-time metric field in non-geodesic LNIF frames[iv]

$$\xi^{\mu}(P) = L_p^{*2}\frac{\partial\arg\Psi(P)}{\partial x^{\mu}} \tag{2.7}$$

The quantum of circulation $\hbar/m$ is replaced by a "quantum of area" L_p^{*2} that may be a variable scale-dependent running coupling constant like what is seen in renormalization group flows to a fixed point. The precise physical explanation of the macro-quantum order parameter in (2.7) in terms of a vacuum condensate of bound virtual electron-positron pairs will be discussed in more detail below.

Where Einstein's smooth curved space-time metric field is the elastic strain tensor

$$\begin{gathered} g^{\mu\nu}(P) = \eta^{\mu\nu} + \frac{1}{2}\left(\frac{\partial\xi^{\mu}}{\partial x^{\nu}} + \frac{\partial\xi^{\nu}}{\partial x^{\mu}}\right) \\ \eta^{\mu\nu} = \begin{matrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{matrix} \end{gathered} \tag{2.8}$$

The local passive general coordinate transformations between different charts at the same space-time event P are derived from local phase transformations on $\arg\Psi(P)$

$$\begin{gathered} \arg\Psi(P) \to \arg\Psi'(P) = \arg\Psi(P) + \chi(P) \\ \xi^{\mu}(P) \to \xi'^{\mu}(P) = \xi^{\mu}(P) + \frac{\partial\chi(P)}{\partial x^{\mu}} \end{gathered} \tag{2.9}$$

$$\frac{\partial x^{\mu'}}{\partial x^{\mu}}(P) \equiv L_p^{*2}\frac{\partial^2\chi(P)}{\partial x^{\mu}\partial x^{\mu'}} \tag{2.10}$$

In general[v] these mixed second order partial derivatives of the gauge function need not commute, i.e. anholonomy in the passive local general coordinate transformations corresponding to a stringy phase singularity in the gauge function $\chi(P)$.

$$g^{\mu'\nu'}(P) \equiv \frac{\partial x^{\mu'}}{\partial x^{\mu}}(P)\frac{\partial x^{\nu'}}{\partial x^{\nu}}(P)g^{\mu\nu}(P) \tag{2.11}$$

The Levi-Civita metric connection for parallel transport of tensor fields relative to other tensor fields in the smooth curved space-time with zero torsion is given by the usual formula from first partial derivatives of the metric field in (2.8). The smooth local nature of space-time gravity physics comes directly from the false micro-quantum $\rightarrow$ true macro-quantum vacuum phase transition, which in the large-scale limit is the inflationary cosmology. The quantum gravity foam models embodied in string theory and Ashtekar's spin foam models suggest a deviation in the energy-momentum "mass shell" for high energy cosmic rays coming from the very early universe. So far experiments have not shown any such quantum foam effect. If my theory here is correct, it suggests that the quantum foam is suppressed because Einstein's gravity is an emergent macro-quantum effect and is not a fundamental micro-quantum field. Fundamental micro-quantum fields are renormalizable and Einstein's gravity is not just as Fermi's theory of beta radio-activity is not renormalizable but emerges from the SU(2) local gauge force theory, which is renormalizable.

The base space world crystal warp field $\xi^{\mu}(P)$ is the LNIF tetrad field with tetrad components $\varsigma_a^{\mu}(P)$ and their orthonormal duals in terms of which Einstein's local equivalence principle is

$$\xi^{\mu}(P)=\varsigma_a^{\mu}(P)e^a \tag{2.12}$$

Where the timelike geodesic LIF basic vectors of the Cartan mobile in the tangent vector fiber space are e^a that transform as the matrix elements of the 6-parameter Lorentz group of 3 space-space rotations and 3 space-time rotations or Lorentz boosts between coincident LIFs in relative motion where the space-time rotation angle is the "rapidity."

$$e^{a'}=\varpi_a^{a'}e^a \tag{2.13}$$

There is also a rotational field of non-integrable anholonomy

$$\omega^{\mu\nu}(P)\equiv\left(\frac{1}{2}\right)\left(\frac{\partial\xi^{\mu}}{\partial x^{\nu}}-\frac{\partial\xi^{\nu}}{\partial x^{\mu}}\right)=\left(\frac{L_p^{*2}}{2}\right)\left(\frac{\partial^2}{\partial x^{\nu}\partial x^{\mu}}-\frac{\partial^2}{\partial x^{\mu}\partial x^{\nu}}\right)\arg\Psi(P) \tag{2.14}$$

The question here is: Does this field always vanish everywhere for commuting mixed second order partial derivatives of the phase if the local Lorentz group is not locally gauged to get compensating torsion fields? The breakdown of integrability, i.e. breakdown of path independence in the phase of the macro-quantum coherent local order parameter, is a stringy singularity[vi] like a quantized flux vortex line in the Goldstone phase $\arg\Psi(P)$ where the Higgs field intensity vanishes inside the vortex core, i.e.

$$\left|\Psi(P)\right|^2\rightarrow 0 \tag{2.15}$$

The order parameter may be "charged." In that case the partial derivatives are replaced with gauge connection covariant partial derivatives for parallel transport in the internal symmetry fiber space. Even though the virtual electron-positron pair vacuum condensate has average electric charge zero, the virtual quanta have magnetic moments or "spintronic" non-minimal couplings of the magnetic moments to the applied electromagnetic fields and, therefore, the gauge covariant partial derivatives will be needed. For now I neglect the parity-violating weak and the strong force couplings. The virtual electrons and positrons of course do not directly couple to the strong gluons, but the weak coupling must be included as the model develops more. Note that an electric field pulse applied to a virtual electron-positron pair does produce a net virtual electric current response even though the total charge is zero. The current 4-vector density is spacelike.

BCS Nonperturbative Dynamics from Microscopic Substratum's "False Vacuum"

As preparation for the off-mass-shell electrically neutral vacuum elastic super-solid of virtual electron-positron pairs, let us review the BCS model[vii] of the on-mass-shell electrically charged supercurrents of real electron pairs in a metal. Consider a pair of real electrons in a thin energy shell that interact above a "quiescent Fermi sphere" exchanging both virtual photons and virtual phonons from the crystal lattice such that the virtual phonon exchange is attractive and overpowers the repulsion between like charges from the virtual photon exchange. The non-perturbative BCS model gives the nonanalytic formula for the macroscopic eigenvalue N_0 of the electron-pair reduced quantum density matrix

$$\begin{aligned} &N_0 \sim 2\rho\left(E_f\right)\hbar\omega_D e^{-1/\rho\left(E_f\right)U_{k_f}} >> 1 \\ &U_{k_f} \sim -\frac{\left|\mathrm{M}_{k_f}\right|^2}{\hbar\omega_D} + \frac{4\pi e^2}{V\vec{k}_f^{\,2}} < 0 \\ &\left|\rho\left(E_f\right)U_{k_f}\right| << 1 \end{aligned} \tag{3.1}$$

The first term in the middle equation of (3.1) is the attractive electron-phonon Frohlich interaction. The positive term is the repulsive Coulomb interaction. The total number of pairs in the ground state condensate is N_0, $\rho\left(E_f\right) > 0$ is the density of electron states *per unit energy* at the Fermi surface of energy E_f and momentum k_f. The physical volume occupied by the electron pair is V. The effective spatial Fourier component of the interaction potential energy at the Fermi wave vector is U_{k_f}. The tiny energy gap difference $\Delta \sim k_B T_c$ per electron pair between the "false vacuum" normal metal ground state and the "true vacuum" superconducting ground state is the binding energy of the pair and critical temperature T_c that is given in

$$\begin{aligned} &\frac{\Delta}{\hbar\omega_D} \sim e^{1/\rho\left(E_f\right)U_k} << 1 \\ &\rho\left(E_f\right)U_k < 0 \end{aligned} \tag{3.2}$$

The "normal fluid" random quasi-particle elementary excitations above the superconducting ground state that will cause electrical resistance and weaken the exclusion of magnetic flux in the Meissner effect have the "mass shell" spectrum

$$\varepsilon_k \sim \Delta + \frac{\left(\hbar\vec{k}\right)^2}{2\Delta/c^2} + \ldots \tag{3.3}$$

One can see heuristically how to make the analogy with the globally flat relativistic false vacuum of massless virtual negative energy electrons filling a Fermi sphere in a world crystal lattice of unit cell size $\sim L_p^*$ where the virtual electron-positron pair interaction is already attractive, to get

$$
\begin{aligned}
&N_{e^+e^-} \sim 2\rho\left(E_f\right)\frac{\hbar c}{L_p^*}e^{-1/\rho\left(E_f\right)U_{k_f}} >> 1 \\
&U_{k_f} \sim -L_p^*\frac{\left|\mathrm{M}_{k_f}\right|^2}{\hbar c} - \frac{4\pi e^2}{L_p^{*3}\vec{k}_f^{\,2}} < 0 \\
&\left|\rho\left(E_f\right)U_{k_f}\right| << 1 \\
&E_f = 0
\end{aligned}
\tag{3.4}
$$

$$
m_e \sim \frac{\hbar}{cL_p^*}e^{1/\rho\left(E_f\right)U_k} \sim \frac{1}{2}10^6 ev \tag{3.5}
$$

$$
\varepsilon^2 = \left(m_e c^2\right)^2 + \left(\hbar\vec{k}\right)^2 \tag{3.6}
$$

This is a primitive toy model Higgs mechanism where the "electron" gets its gravitational inertia (rest mass) from the vacuum coherence where

$$
\Psi_{e^+e^-} \approx \sqrt{2\rho\left(E_f\right)\frac{\hbar c}{L_p^*}e^{-1/\rho\left(E_f\right)U_{k_f}}}\, e^{i\arg\Psi_{e^+e^-}} \tag{3.7}
$$

Einstein's Cosmological Constant Paradox Explained?

The paradox is that conventional quantum field theory without any vacuum coherence implies that

$$
\Lambda \sim \frac{1}{L_p^{*2}} \approx 10^{66} cm^{-2} \tag{4.1}
$$

But observations of dark energy $\Omega_{DE} \sim 0.73 \pm 0.02$ in Type 1a supernovae standard candles from at least two competing independent groups of observers imply that, in terms of the absolute temperature of the cosmic black body radiation CBB

$$
\begin{aligned}
&\Lambda \sim \left(\frac{H_0}{c}\right)^2 \sim 10^{-56} cm^{-2} \\
&H(t) \equiv R(t)^{-1}\frac{dR(t)}{dt} \\
&t \sim \frac{\hbar}{k_B T_{CBB}}
\end{aligned}
\tag{4.2}
$$

The discrepancy between orthodox quantum field theory in globally flat space-time with completely incoherent random zero point vacuum fluctuations and observation is 56 + 66 = 122 powers of ten! I have solved this most inconvenient paradox.

It is well known that Einstein's equivalence principle combined with Heisenberg's uncertainty principle together with Lorentz and general coordinate covariance of the local field laws of physics imply that the zero point vacuum fluctuations of all quantum fields[viii] contribute to a term $\sim \Lambda g_{\mu\nu}(P)$ in Einstein's smooth gravity field equation

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$
$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} \tag{4.3}$$

The cosmological constant Λ need not be a constant in general, but it is assumed to be in the large-scale cosmological limit > 10^2 Megaparsecs where we make the FRW assumption of isotropy and homogeneity tacit in the opening section of this paper. However, in general we consider a variable scale-dependent local field $\Lambda_{zpf}(P)$ that limits to Einstein's cosmological constant in the large scale, however it retains a direct physical meaning on all scales. Indeed, in the spirit of the phenomenological two fluid models of macro-quantum liquids and elastic super solids, I make the Ansatz

$$\Lambda_{zpf}(P) = \frac{1}{L_p^{*2}} \left(L_p^{*3} \left| \Psi_{e^+e^-}(P) \right|^2 - 1 \right) \tag{4.4}$$

Therefore, there is an optimum Higgs field intensity $\left| \Psi_{e^+e^-}(P) \right|^2 \sim 1/L_p^{*3}$ for the complex vacuum coherence field such that $\Lambda_{zpf}(P) \approx 0$. Indeed, $\Lambda_{zpf}(P)$ can have either sign! The sign conventions here are such that a positive $\Lambda_{zpf}(P)$ anti-gravitates (universally repels) as "dark energy" and a negative $\Lambda_{zpf}(P)$ gravitates as "dark matter." This is why dark matter detectors can never click with real on-mass-shell exotic particles if this theory is correct. Indeed, it appears that supersymmetry has no basis in fact, though it is a pretty formal idea. The weak field Poisson equation for the gravity or anti-gravity of exotic vacuum induced by residual random incoherent net zero point energy density is from (1.4) in this w = -1 case of the partially coherent vacuum

$$\nabla^2 V_{exotic\_vacuum} = -8\pi c^2 \Lambda_{zpf} \tag{4.5}$$

Warp Drive and Zero Point Energy[ix]

Alcubierrie's toy model zero g-force free float time-like geodesic warp "reactionless drive" without time dilation in the ADM 3+1 representation starts with a shift-only trivial lapse function metric form for a "unconventional flying object" with

$$ds^2 = -(cdt)^2 + \left[d\vec{r} - \vec{\beta}(x, y, z - z_0(t))dt \right]^2 \tag{5.1}$$

The ADM space-like shift 3-vector is $\vec{\beta}$ that is the "gravimagnetic field."[x] The space-like surfaces of this foliation are flat, but the extrinsic curvature is the 3D elastic strain tensor

$$K^{ij} = \frac{1}{2}\left(\frac{\partial \beta^j}{\partial x^i} + \frac{\partial \beta^i}{\partial x^j}\right)$$
$$i, j = 1,2,3 = x, y, z \quad (5.2)$$

$$Tr(K) \equiv TrK^{ij} \equiv \sum_{i=1}^{3} K^{ii} = \vec{\nabla} \cdot \vec{\beta} \sim \vartheta \quad (5.3)$$

This divergence of the gravimagnetic field is, in analogy with Maxwell's electromagnetic field, a gravimagnetic pole density ϑ that is the expansion/contraction of volume elements of space in exotic vacua. Alcubierre then assumes motion along the z axis

$$\vec{\beta} = v(t) f\left(x, y, z - z_0(t)\right)\hat{z} \quad (5.4)$$

Assume spherical symmetry for simplicity

$$f \to f\left(r(t)\right)$$
$$r(t) = \sqrt{\left[z - z_0(t)\right]^2 + x^2 + y^2} \quad (5.5)$$

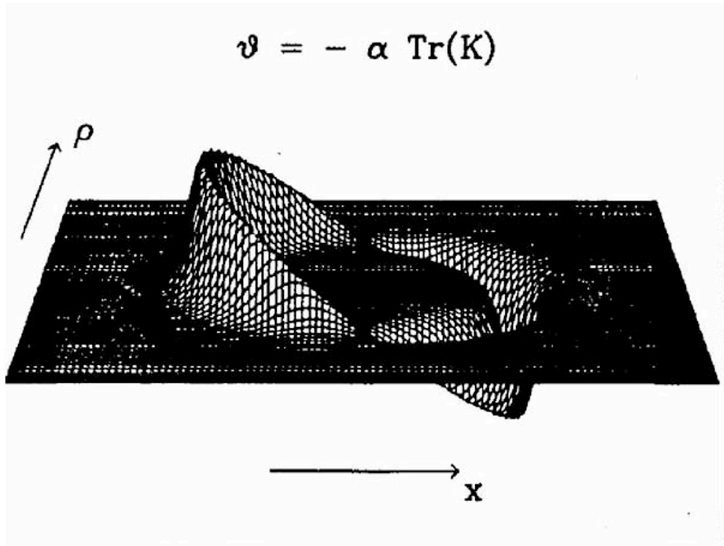
"Eulerian observers" located at $z_0(t)$ have the 4-velocity, they are in the rest frame of the "unconventional flying object" approximated here as a point test particle[xi]

$$U^{\mu} = \left(1,0,0,\frac{v}{c} f\right) \quad (5.6)$$

The 4-acceleration vanishes, hence the Eulerian observers are locally always on a time-like geodesic, which by definition has no time dilation. The proper time along the world line of the Eulerian observer on the unconventional flying object in warp drive is the same as the coordinate time. The twin that is younger is always the one that has moved on a timelike non-geodesic for some part of its history assuming the twins leave from same event and meet at a different event to compare their proper durations from start to finish. Globally, relative to a distant observer, the "unconventional flying object" can go at effective warp speed greater than light similar to the faster than light aspect of the inflating space of the universe. Locally there is no violation of the speed of light. Locally, the objects inside the saucer are continually in zero g-force weightless free float no matter how curved the flight path looks to an outside observer. The expansion of volume elements is defined as the covariant divergence of the 4-velocity of the Eulerian pilot inside this admittedly simplistic toy model[xii] of a "unconventional flying object" reaction-less drive using the *springiness of the exotic vacuum* with some residual total zero point energy density at the relevant scale. Following Lobo and Visser[xiii] in this section

$$\vartheta \equiv U^{\mu}{}_{;\mu} = \frac{v}{c}\frac{\partial f}{\partial z} = \frac{v}{c}\frac{z - z_0}{r}\frac{df}{dr} \sim \vec{\nabla} \cdot \vec{\beta} \quad (5.7)$$

Alcibierre's basic idea is a controlled inflationary expansion of space at the stern of the unconventional flying object and a controlled inflationary compression of space at the bow. The field configuration of ϑ is given by Alcubierre's famous picture



Tr(K) ~ Divergence of Gravimagnetic Field ~ Λzpf
Components of Gravimagnetic Field 3-vector = goi

Note that α is the lapse function in the ADM formalism, which is trivial $\alpha = 1$ in this toy model. My idea here is that the expansion warp of space is provided by an exotic vacuum distribution of negative quantum pressure and a region of positive quantum pressure provides the contraction warp of space. The space-time stiffness factor $8\pi G/c^4 \sim 10^{-33} cm/10^{19}\, Gev$ multiplying $T_{\mu\nu}$ is bypassed in the $\Lambda_{zpf}\, g_{\mu\nu}$ term of Einstein's local field equation for the smooth curved space-time emergent from the undulations in the Goldstone phase of the predominately virtual electron-positron vacuum condensate. Although the precise metric investigated here is not suitable for zero point energy powered reaction-less warp drive, Alcubierre's famous picture above does show the qualitative features that a more complete metric model with appropriate connection field must obey. To repeat, if the unconventional flying object is moving to the right in the above picture (note "x" in the picture is "z" in the math below) then $\Lambda_{zpf} > 0$ with negative exotic vacuum quantum pressure causing the repulsive stretch of 3D space in the stern of the saucer as well as an anomalous universal blue shift of any kind of radiating signals that oppose the normal motional Doppler shift. This feature obviously has "STEALTH" implications. Similarly, $\Lambda_{zpf} < 0$ with positive exotic vacuum quantum pressure attractively squeezing 3D space at the bow causing an anomalous universal red shift. Indeed, in principle, one can cloak signals transmitted by or "radar" reflected from the saucer.

The Einstein tensor components

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} \quad (5.8)$$

for the admittedly unrealistic over-simplified generic toy shift-only warp drive metric are given by Lubo and Visser as follows. First the mixed space-time components:

$$G_{\hat{t}\hat{x}} = -\frac{1}{2}\left(\frac{v}{c}\right)\frac{\partial^2 f}{\partial x \partial z}$$
$$G_{\hat{t}\hat{y}} = -\frac{1}{2}\left(\frac{v}{c}\right)\frac{\partial^2 f}{\partial y \partial z} \tag{5.9}$$
$$G_{\hat{t}\hat{z}} = \frac{1}{2}\left(\frac{v}{c}\right)\left(\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}\right)$$

Next, the off-diagonal space-space plus the diagonal components:

$$G_{\hat{x}\hat{y}} = \frac{1}{2}\left(\frac{v}{c}\right)^2\left(\frac{\partial f}{\partial y}\right)\left(\frac{\partial f}{\partial x}\right)$$
$$G_{\hat{x}\hat{z}} = \left(\frac{v}{c}\right)^2\left[\left(\frac{\partial f}{\partial z}\right)\left(\frac{\partial f}{\partial x}\right) - \frac{1}{2}(1-f)\frac{\partial^2 f}{\partial x \partial z}\right]$$
$$G_{\hat{y}\hat{z}} = \left(\frac{v}{c}\right)^2\left[\left(\frac{\partial f}{\partial z}\right)\left(\frac{\partial f}{\partial y}\right) - \frac{1}{2}(1-f)\frac{\partial^2 f}{\partial y \partial z}\right]$$
$$G_{\hat{x}\hat{x}} = \left(\frac{v}{c}\right)^2\left[\frac{1}{4}\left(\frac{\partial f}{\partial x}\right)^2 - \frac{1}{4}\left(\frac{\partial f}{\partial y}\right)^2 - \left(\frac{\partial f}{\partial z}\right)^2 + (1-f)\frac{\partial^2 f}{\partial z^2}\right] \tag{5.10}$$
$$G_{\hat{y}\hat{y}} = \left(\frac{v}{c}\right)^2\left[\frac{1}{4}\left(\frac{\partial f}{\partial y}\right)^2 - \frac{1}{4}\left(\frac{\partial f}{\partial x}\right)^2 - \left(\frac{\partial f}{\partial z}\right)^2 + (1-f)\frac{\partial^2 f}{\partial z^2}\right]$$
$$G_{\hat{z}\hat{z}} = -\frac{3}{4}\left(\frac{v}{c}\right)^2\left[\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2\right]$$
$$G_{\hat{t}\hat{t}} = -\frac{1}{4}\left(\frac{v}{c}\right)^2\left[\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2\right]$$

The vacuum bubble form function f, its first partial and second partial space derivatives form a set of 7 arbitrary functions that appear in the above Einstein tensor components. I assume holonomy that the mixed second order partials of f commute. If there is anholonomy we get 2 more arbitrary functions for a total of 9 and we need to modify the above equations, i.e. symmetrize them in the off-diagonal space-space second partials of f that appear. Now let us see if the above warp drive expressions are consistent with exotic vacuum quantum pressure field distributions. The exotic vacuum field equation, neglecting the conventional matter source term as a small perturbation is

$$G_{\mu\nu} + \Lambda_{zpf} g_{\mu\nu} \approx 0 \tag{5.11}$$

The covariant 4-divergence for the flow of vacuum stress-energy density currents of "reaction-less propulsion" is

$$G_{\mu\nu}{}^{;\nu} + \frac{\partial \Lambda_{zpf}}{\partial x^\nu} g_{\mu\nu} + \Lambda_{zpf} g_{\mu\nu}{}^{;\nu} \approx 0 \tag{5.12}$$

I include the possibility of non-metricity, the covariant derivative denoted by the semi-colon is relative to a connection that I leave unspecified because that requires a paper by itself. Gennady Shipov in Moscow is working on the connection with antisymmetric torsion that comes from locally gauging the entire 10-parameter Poincare group of the unstable globally flat "false vacuum" of special relativistic quantum field theory and even modern superstring theory. The latter has not passed any experimental tests and some experts like Peter Woit at Columbia University Math Department, same department as Brian Greene claims, in his Blog "Not Even Wrong" that Pauli's bon-mot applies to string theory. Tony Smith has suggested that the entire 15 parameter conformal group be locally gauged. That makes more sense because the globally flat pre-inflation false vacuum without any emergent "More is different" (P.W. Anderson) cannot support any real massive excitations – the equivalence of gravity and inertia forbids! Einstein's gravity depends on the "phase rigidity" of the vacuum coherence local field in the true super-solid post-inflationary vacuum that we live on. Therefore, my Ansatz is that the relevant connection field depends on all the dynamical compensating fields from locally gauging all the continuous symmetry groups both space-time and internal – curvature, torsion and beyond. The covariant Landau-Ginzburg equation for the dynamics of the vacuum coherence is

$$\begin{aligned} &\Box_{\nu}^{\nu}\Psi_{e^+e^-} + \omega^2\Psi_{e^+e^-} + \kappa\left|\Psi_{e^+e^-}\right|^2\Psi_{e^+e^-} = 0 \\ &\omega^2 < 0 \\ &\kappa > 0 \end{aligned} \tag{5.13}$$

This generalizes the chaotic inflationary cosmology of an infinity of infinity of parallel universes in the hyperspace of Super Cosmos called "Level I" and "Level II" by Max Tegmark in the May 2003 issue of Scientific American. I also provide here the micro-quantum dynamics for the emergence of inflation previously lacking in the pure phenomenology of A. Linde & Co. The pre- inflationary globally flat false vacuum does not locally gauge any of the space-time group. It does locally gauge the internal symmetry groups U(1)xSU(2)xSU(3) *without* any Higgs mechanism! The Higgs mechanism is post-inflationary only. Real matter $\Omega_{matter} \sim 0.04$ does not exist in the false vacuum. The false vacuum has

$$\omega^2 > 0 \tag{5.14}$$

The covariant wave propagation operator is $\Box_{\nu}^{\nu}$ and it depends in its fullness on the choice of connection field that, in turn, depends on which continuous symmetry groups of the invariant dynamical action are locally gauged. Note that Marshall Stoneham and I first wrote these basic equations in the summer of 1966 at UKAEA, Harwell, for Galilean relativity in the course of solving a practical solid-state physics problem. This paper "The Goldstone Theorem and the Jahn-Teller Effect" was published in the Proceedings of the Physical Society of London in 1967 and is cited in the American Institute of Physics "Resource Letter on Symmetry in Physics."

"The Question is: What is The Question?" said John Archibald Wheeler in Philadelphia, April 2003 APS. Obviously we must solve (5.11), (5.13), (2.8) and (4.4) self-consistently in, for example, the FRW limit cosmology to compute the time evolution of $\Lambda(t)$. I hope the others will now start working on doing so.

Returning to the Alcubierre warp drive toy model. The independent non-vanishing symmetric metric components are:

$$
\begin{aligned}
&g_{\hat{t}\hat{t}} = -1 \\
&g_{\hat{x}\hat{x}} = g_{\hat{y}\hat{y}} = g_{\hat{z}\hat{z}} = +1 \\
&g_{\hat{z}\hat{t}} = -\frac{v}{c} f
\end{aligned}
\tag{5.15}
$$

Therefore combining (5.9), (5.10) and (5.15) in (5.11) does not work. The only consistent solution demands $\Lambda_{zpf} \approx 0$. Therefore, the original unrealistic Alcubierre toy model warp drive metric with a point-like unconventional flying object is too simplistic to be implemented by controlled partially coherent exotic vacuum zero point energy density. The zero-point energy powered warp drive metrics must be computed from scratch and this will be done in a future paper. Of course, the results will depend critically on the choice of connection fields, e.g. is there torsion, non-metricity, compensating fields from locally gauging the 4 special conformal boosts to constant proper acceleration (hyperbolic) motion, and dilation?[xiv]

$$
\begin{aligned}
&G_{\hat{t}\hat{x}} = -\frac{1}{2}\left(\frac{v}{c}\right)\frac{\partial^2 f}{\partial x \partial z} \approx 0 \\
&G_{\hat{t}\hat{y}} = -\frac{1}{2}\left(\frac{v}{c}\right)\frac{\partial^2 f}{\partial y \partial z} \approx 0 \\
&G_{\hat{t}\hat{z}} = \frac{1}{2}\left(\frac{v}{c}\right)\left(\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}\right) \approx \Lambda_{zpf}\left(\frac{v}{c}\right) f \rightarrow \frac{1}{2}\left(\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}\right) \equiv \nabla^2_{2D} f \approx \Lambda_{zpf} f \\
&G_{\hat{x}\hat{y}} = \frac{1}{2}\left(\frac{v}{c}\right)^2 \left(\frac{\partial f}{\partial y}\right)\left(\frac{\partial f}{\partial x}\right) \approx 0 \\
&G_{\hat{x}\hat{z}} = \left(\frac{v}{c}\right)^2 \left[\left(\frac{\partial f}{\partial z}\right)\left(\frac{\partial f}{\partial x}\right) - \frac{1}{2}(1-f)\frac{\partial^2 f}{\partial x \partial z}\right] \approx 0 \\
&G_{\hat{y}\hat{z}} = \left(\frac{v}{c}\right)^2 \left[\left(\frac{\partial f}{\partial z}\right)\left(\frac{\partial f}{\partial y}\right) - \frac{1}{2}(1-f)\frac{\partial^2 f}{\partial y \partial z}\right] \approx 0 \\
&G_{\hat{x}\hat{x}} = \left(\frac{v}{c}\right)^2 \left[\frac{1}{4}\left(\frac{\partial f}{\partial x}\right)^2 - \frac{1}{4}\left(\frac{\partial f}{\partial y}\right)^2 - \left(\frac{\partial f}{\partial z}\right)^2 + (1-f)\frac{\partial^2 f}{\partial z^2}\right] \approx -\Lambda_{zpf} \\
&G_{\hat{y}\hat{y}} = \left(\frac{v}{c}\right)^2 \left[\frac{1}{4}\left(\frac{\partial f}{\partial y}\right)^2 - \frac{1}{4}\left(\frac{\partial f}{\partial x}\right)^2 - \left(\frac{\partial f}{\partial z}\right)^2 + (1-f)\frac{\partial^2 f}{\partial z^2}\right] \approx -\Lambda_{zpf} \\
&G_{\hat{z}\hat{z}} = -\frac{3}{4}\left(\frac{v}{c}\right)^2 \left[\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2\right] \approx -\Lambda_{zpf} \\
&G_{\hat{t}\hat{t}} = -\frac{1}{4}\left(\frac{v}{c}\right)^2 \left[\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2\right] \approx \Lambda_{zpf}
\end{aligned}
\tag{5.16}
$$

Simplify the above equations to

$$\begin{aligned}
&\frac{\partial^2 f}{\partial x \partial z} \approx 0 \\
&\frac{\partial^2 f}{\partial y \partial z} \approx 0 \\
&\nabla^2_{2D} f \approx \Lambda_{zpf} f \\
&\left(\frac{\partial f}{\partial y}\right)\left(\frac{\partial f}{\partial x}\right) \approx 0 \\
&\left(\frac{\partial f}{\partial z}\right)\left(\frac{\partial f}{\partial x}\right) \approx 0 \\
&\left(\frac{\partial f}{\partial z}\right)\left(\frac{\partial f}{\partial y}\right) \approx 0 \\
&G_{\hat{x}\hat{x}} = \left(\frac{v}{c}\right)^2 \left[-\left(\frac{\partial f}{\partial z}\right)^2 + (1-f)\frac{\partial^2 f}{\partial z^2} \right] \approx -\Lambda_{zpf} \\
&0 \approx -\Lambda_{zpf}
\end{aligned} \tag{5.17}$$

On the other hand return to (5.1) and use a non-trivial lapse or red/blue shift function α , the more general metric is then

$$ds^2 = -\left(\alpha^2 - \sum_{i=1}^{3} \gamma_{ij}\beta^i\beta^j\right)(cdt)^2 + 2dt\sum_{i=1}^{3}\beta_i dx^i + \sum_{i=1}^{3}\sum_{j=1}^{3}\gamma_{ij}dx^i dx^j \tag{5.18}$$

Use of a non-trivial lapse function α will cause time dilation in which at the location of the unconventional flying object

$$\frac{ds}{c} \neq dt \tag{5.19}$$

We usually want to avoid this. At the very least we need to introduce transverse components of the gravimagnetic field shift functions

$$\begin{aligned}
\beta_1 &\equiv g_{\hat{t}\hat{x}} \\
\beta_2 &\equiv g_{\hat{t}\hat{y}}
\end{aligned} \tag{5.20}$$

It also helps to have “gravielectric” fields, i.e. off-diagonal space-space components of the 3D spacelike metric. Spatial curvature seemingly cannot be avoided if there is zero point energy density reactionless propulsion, but its tidal stretch-squeeze must be small over the scale of the saucer. Therefore, (5.16) is replaced by

$$
\begin{aligned}
G_{\hat{t}\hat{x}} &= -\frac{1}{2}\left(\frac{v}{c}\right)\frac{\partial^2 f}{\partial x \partial z} \approx \Lambda_{zpf}\beta_1 \neq 0 \\
G_{\hat{t}\hat{y}} &= -\frac{1}{2}\left(\frac{v}{c}\right)\frac{\partial^2 f}{\partial y \partial z} \approx \Lambda_{zpf}\beta_2 \neq 0 \\
G_{\hat{t}\hat{z}} &= \frac{1}{2}\left(\frac{v}{c}\right)\left(\frac{\partial^2 f}{\partial x^2}+\frac{\partial^2 f}{\partial y^2}\right) \approx \Lambda_{zpf}\left(\frac{v}{c}\right) f \to \frac{1}{2}\left(\frac{\partial^2 f}{\partial x^2}+\frac{\partial^2 f}{\partial y^2}\right) \equiv \nabla^2_{2D} f \approx \Lambda_{zpf} f \\
G_{\hat{x}\hat{y}} &= \frac{1}{2}\left(\frac{v}{c}\right)^2\left(\frac{\partial f}{\partial y}\right)\left(\frac{\partial f}{\partial x}\right) \approx \Lambda_{zpf}\gamma_{\hat{x}\hat{y}} \\
G_{\hat{x}\hat{z}} &= \left(\frac{v}{c}\right)^2\left[\left(\frac{\partial f}{\partial z}\right)\left(\frac{\partial f}{\partial x}\right)-\frac{1}{2}(1-f)\frac{\partial^2 f}{\partial x \partial z}\right] \approx \Lambda_{zpf}\gamma_{\hat{x}\hat{z}} \\
G_{\hat{y}\hat{z}} &= \left(\frac{v}{c}\right)^2\left[\left(\frac{\partial f}{\partial z}\right)\left(\frac{\partial f}{\partial y}\right)-\frac{1}{2}(1-f)\frac{\partial^2 f}{\partial y \partial z}\right] \approx \Lambda_{zpf}\gamma_{\hat{y}\hat{z}} \\
G_{\hat{x}\hat{x}} &= \left(\frac{v}{c}\right)^2\left[\frac{1}{4}\left(\frac{\partial f}{\partial x}\right)^2-\frac{1}{4}\left(\frac{\partial f}{\partial y}\right)^2-\left(\frac{\partial f}{\partial z}\right)^2+(1-f)\frac{\partial^2 f}{\partial z^2}\right] \approx -\Lambda_{zpf} \\
G_{\hat{y}\hat{y}} &= \left(\frac{v}{c}\right)^2\left[\frac{1}{4}\left(\frac{\partial f}{\partial y}\right)^2-\frac{1}{4}\left(\frac{\partial f}{\partial x}\right)^2-\left(\frac{\partial f}{\partial z}\right)^2+(1-f)\frac{\partial^2 f}{\partial z^2}\right] \approx -\Lambda_{zpf} \\
G_{\hat{z}\hat{z}} &= -\frac{3}{4}\left(\frac{v}{c}\right)^2\left[\left(\frac{\partial f}{\partial x}\right)^2+\left(\frac{\partial f}{\partial y}\right)^2\right] \approx -\Lambda_{zpf} \\
G_{\hat{t}\hat{t}} &= -\frac{1}{4}\left(\frac{v}{c}\right)^2\left[\left(\frac{\partial f}{\partial x}\right)^2+\left(\frac{\partial f}{\partial y}\right)^2\right] \approx \Lambda_{zpf}
\end{aligned}
\tag{5.21}
$$

Inflationary Cosmology Model

The BIT FROM IT Landau-Ginzburg equation for the macro-quantum vacuum coherence field Ψ :

$$
\ddot{\Psi} + 3H\dot{\Psi} = -\frac{\partial V(\Psi)}{\partial \Psi *} \tag{5.22}
$$

The dimensionless Hubble cosmological factor for FRW scale factor $R(t)$ is:

$$
H \equiv \frac{\dot{R}}{R} \tag{5.23}
$$

The IT FROM BIT Einstein field equation is:

$$
H^2 + \frac{c^2 k}{L_p{}^2 R^2} = L_p{}^3\left(\frac{1}{2}\dot{\Psi}^2 + V(\Psi)\right) + c^2\Lambda \tag{5.24}
$$

Observation shows $k = 0 \rightarrow \Omega = 1$. The vacuum coherence potential $V(\Psi)$ has dimensions (volume)$^{-1}$(time)$^{-2}$, i.e. potential energy density per unit test particle mass per unit volume.

$$L_p{}^2 \equiv \frac{\hbar G}{c^3} \approx \left(10^{-33}cm\right)^2 \tag{5.25}$$

The cosmological constant Λ controlled by the vacuum coherence is:

$$\Lambda \equiv \frac{1}{L_p{}^2}\left(L_p{}^3|\Psi|^2 - 1\right) \tag{5.26}$$

The effective potential of the vacuum coherence with spontaneous broken symmetry is something like:

$$\begin{aligned} &V(\Psi) = \alpha|\Psi|^2 + \beta|\Psi|^4 \\ &\alpha < 0 \\ &\beta > 0 \end{aligned} \tag{5.27}$$

Therefore,

$$\begin{aligned} &H^2 + \frac{c^2 k}{L_p{}^2 R^2} = L_p{}^3\left(\frac{1}{2}\dot{\Psi}^2 + V(\Psi)\right) + \frac{c^2}{L_p{}^2}\left(L_p{}^3|\Psi|^2 - 1\right) \\ &\rightarrow L_p{}^3\left(\frac{1}{2}\dot{\Psi}^2 + \alpha|\Psi|^2 + \beta|\Psi|^4\right) + \frac{c^2}{L_p{}^2}\left(L_p{}^3|\Psi|^2 - 1\right) \\ &= L_p{}^3\left(\frac{1}{2}\dot{\Psi}^2 + \left(\alpha + \frac{c^2}{L_p{}^2}\right)|\Psi|^2 + \beta|\Psi|^4\right) - \frac{c^2}{L_p{}^2} \end{aligned} \tag{5.28}$$

The FRW metric can be written as

$$\begin{aligned} &ds^2 = (cdt)^2 - L_p{}^2 R(t)^2\left[d\chi^2 + S_k(\chi)^2\left(d\theta^2 + \sin^2\theta d\phi^2\right)\right] \\ &\chi \equiv 2\pi\frac{r}{L_p} \end{aligned} \tag{5.29}$$

k	$S_k(\chi)$	3D Space Curvature
+1	$\sin(r/L_p)$	Closed Elliptical Universe
0	r/L_p	Open Parabolic Universe
-1	$\sinh(r/L_p)$	Open Hyperbolic Universe

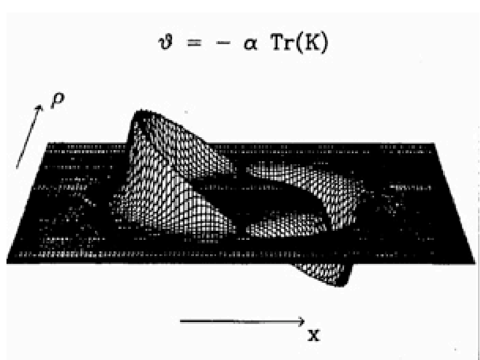
Therefore, from (2.7) and 2.8

$$
\begin{aligned}
&g^{\mu\nu}(P) = \eta^{\mu\nu} + \frac{1}{2}\left(\frac{\partial \xi^{\mu}}{\partial x^{\nu}} + \frac{\partial \xi^{\nu}}{\partial x^{\mu}}\right) \\
&\eta^{\mu\nu} = \begin{matrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{matrix} \\
&g^{\hat{t}\hat{t}} = 1 \rightarrow \frac{\partial \xi^{\hat{t}}}{\partial x^{\hat{t}}} = L_p{}^2 \frac{\partial^2 \arg \Psi}{c^2 \partial t^2} = 0 \\
&g^{\hat{r}\hat{r}} = -1 + L_p{}^2 \frac{\partial^2 \arg \Psi}{\partial r^2} = -R(t)^2
\end{aligned}
\qquad (5.30)
$$

etc. for all the other second order partial derivatives of the phase of the vacuum coherence.[xv]

Exotic Vacuum Acceleration of Particles

The parameter hG^*/c^3 is of order 10^{-26} cm^2, i.e. $G^* \sim 10^{40}G$ when N = 1 for the internal structure of a single spatially extended electron. G* is scale-dependent and must be determined empirically at this stage of development of theory. The observed anomalous acceleration of EVOs is essentially the Alcubierre warp drive effect where there are configurations of both positive and negative Λ_{zpf} in different parts of the same EVO causing it to self-accelerate. In terms of Alcubierre's exotic source parameter $Tr(K) \sim \Lambda_{zpf}$



The Warp Drive: Hyper-Fast
Travel Within General Relativity
Miguel Alcubierre
Class. Quantum Grav. 11 (1994), L73-L77

A more complete model of Ken Shoulders' EVO's including rotation and Casimir forces.

Virtual photons of all three independent polarizations do have positive energy density hence negative pressure since w = -1 for them. Since the gravity influence of the pressure is three times larger than that of the energy density, these virtual photons do anti-gravitate.

The virtual photons in a static Coulomb electric field, or even in time changing non radiating near induction fields like in electrical equipment are in macro-quantum coherent states as shown, for example by Roy Glauber at Harvard in the early 1960s. These virtual photons are not part of the vacuum zero point fluctuations. They are part of the ordinary stress-energy density tensor $T_{\mu\nu}$ on the RHS of Einstein's field equation

$$G_{\mu\nu} + \Lambda_{zpf} g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \tag{6.1}$$

i.e. macroscopic near EM fields only appear in the $T_{\mu\nu}$ term, not in the $\Lambda_{zpf} g_{\mu\nu}$ term!

Since, $G/c^4 = 10^{-33}$ cm per 10^{19}Gev at least at macro lab scales, we can ignore the direct effect of such classical EM near fields on the metric engineering i.e. shaping of $G_{\mu\nu}$, which comes entirely from the $\Lambda_{zpf} g_{\mu\nu}$ term. That's the key idea for practical metric engineering the fabric of space-time for reaction-less or propellantless propulsion. Metric engineering is strictly "virtual" without "forces" in the above sense. The idea of metric engineering is for the ship's crew to control their own timelike free float geodesic with small tidal stretch-squeeze distortions and using SMALL amounts of onboard power!

Consider a spatially-extended Bohm-Vigier hidden variable model of an electron as a thin shell of electric charge at radius $r = e^2/mc^2 \sim 1$ fermi (10^{-13} cm). Ignore rotation (or spin) for now. Think classically, which is OK for the IT "hidden variable" in Bohm's pilot BIT wave model of NRQM. Relativistic Bohm QM requires teleology to explain EPR nonlocality in a covariant way as the Feynman zig-zag of Costa de Beauregard and later John Cramer taken from Wheeler and Feynman in its first historical incarnation of classical electrodynamics - action at a distance along both light cones advanced from the future and retarded from the past.

The self-Coulomb repulsive barrier potential energy is of order of magnitude

$$U_{self} \approx +\frac{e^2}{r} \tag{6.2}$$

Note the + sign. The gradient magnitude is $-e^2/r^2$, but the force is the negative gradient, hence the force points radially outward.

$$\vec{f}_{self} \equiv -\vec{\nabla} U_{self} \approx +\frac{e^2}{r^2}\hat{r} \tag{6.3}$$

The repulsive QED ZPF Casimir force for a thin spherical cavity comes from a ZPF potential energy

$$U_{zpf} \approx \frac{\hbar c}{r} \approx 137\frac{e^2}{r} \tag{6.4}$$

Therefore the QED repulsive Casimir self-force on the electron modeled as a charged spherical cavity is much stronger than the self Coulomb repulsion. The general relativity quantum pressure correction in the partially coherent exotic vacuum core of this spherical shell must be strong enough to cancel the repulsive Casimir force.

The GR rule for the w = -1 ZPF quantum pressure, is to replace G(effective mass density ρ of real or virtual stuff)(1 + 3w) by $c^2\Lambda_{zpf}$. I neglect factors of π etc. Assume a uniform zero point energy density $\sim\left(c^4/8\pi G*\right)\Lambda_{zpf}$ "core" inside the electron charge thin spherical shell. The effective zero point induced self-gravity "dark energy" potential energy per unit test mass is then the harmonic well "bag" potential

$$V_{GR} \approx c^2\Lambda_{zpf}r^2 > 0 \tag{6.5}$$

Note that potential energy per unit test mass has dimensions (velocity)^2. The simple harmonic oscillator r^2 dependence is same as drilling a hole through the center of the Earth and dropping a bowling ball down through it. Note the counter intuitive result that the general relativistic zero point fluctuation exotic vacuum potential must be positive, i.e. dark energy with negative pressure, to stabilize the electron as a thin shell of charge. All of the energies are positive. The Coulomb, Casimir and rotational centrifugal barrier energies in the rotating frame are also all positive but they decrease with increasing r whereas the general relativistic zero point energy increases with increasing r to make a potential well of stability. This solves the 100 year old Abraham-Becker-Lrentz self-stress problem for the stability of the electron as a spatially extended hard massy object in the sense of Newton and Bohm. The electrical potential energy per unit test mass including the repulsive QED Casimir force is

$$\begin{aligned} V_{self} &= \frac{\hbar c}{mr}\left(\eta_1 + \eta_2\alpha\right) \\ \alpha &\equiv \frac{e^2}{\hbar c} \sim \frac{1}{137} \end{aligned} \tag{6.6}$$

Note that Λ_{zpf} can be zero, positive or negative. Here, of course, the test mass = source mass, i.e. self-energy. The dimensionless extended-structure coefficients of order unity are η_1 & η_2 Suppose the electron is rotating with angular momentum J, the centrifugal potential energy per unit test mass in the rotating frame fixed to the electron is then

$$V_{spin} = \frac{J^2}{2m^2r^2} \tag{6.7}$$

Therefore

$$V_{total} = V_{self} + V_{spin} + V_{GR} = +\frac{\hbar c}{mr}\left(\eta_1 + \eta_2\alpha\right) + \frac{J^2}{2m^2r^2} + c^2\Lambda_{zpf}r^2 \tag{6.8}$$

A necessary condition for stability is that the total force negative gradient of the potential per unit test mass vanishes!

$$
\begin{aligned}
&-\vec{\nabla}V_{total} = \left(\frac{\hbar c}{mr^2}\left(\eta_1+\eta_2\alpha\right)+\frac{J^2}{mr^3}-c^2\Lambda_{zpf}r\right)\hat{r}\to 0\\
&r=\frac{e^2}{mc^2}\\
&J\to\frac{\hbar}{2}
\end{aligned}
\tag{6.9}
$$

$$
\begin{aligned}
&\Lambda_{zpf}=\frac{\hbar}{mcr^3}\left(\eta_1+\eta_2\alpha\right)+\frac{J^2}{m^2c^2r^4}\\
&=\frac{\lambda_{quantum}}{r_{classical}{}^3}\left(\eta_1+\eta_2\alpha\right)+\frac{\lambda_{quantum}{}^2}{r_{classical}{}^4}\\
&\frac{\lambda_{quantum}}{r_{classical}}=\frac{\hbar c}{e^2}=\frac{1}{\alpha}\sim 137\\
&\Lambda_{zpf}=\frac{1}{\alpha r_{classical}{}^2}\left(\eta_1+\eta_2\alpha\right)+\frac{1}{\alpha^2 r_{classical}{}^2}\approx\left(\frac{1}{10^{-15}cm}\right)^2\approx\frac{1}{L_p^{*2}}
\end{aligned}
\tag{6.10}
$$

This is an apriori calculation of the weak force scale mass of the W bosons ~ 10^2Gev. I note again that /\zpf > 0 is required in this particular model! This means a dark energy core not a dark matter core! This counter-intuitive result is because we assume a uniform volume core of zero point energy density and a thin shell of charge at the periphery. The sign of /\zpf is highly model-dependent.

Metric Engineering Control of the Fabric of Space-Time?

Start from a non-exotic vacuum, where the vacuum coherence is optimally set at the given scale such that

$$\Lambda_{zpf}=0 \tag{7.1}$$

Now imagine a macro-quantum control valve. This can be any kind of complex on mass-shell system that has an order parameter than couples to the virtual electron-positron vacuum condensate. P.W. Anderson, in his book “A Career in Theoretical Physics” (World Scientific) comments in several papers that the micro-dynamics of emergent macro-quantum systems effectively cancels out of the problem at the next level of complexity and that the local order parameters are something like giant quantum waves whose “phase rigidity” called “metric elasticity” by Andrei Sakharov in the special case of emergence of smooth curved space-time, gives them the properties we associate with the “classical world.” Therefore, all we need assume as an Ansatz is that the order parameter of the control valve will coherently interfere with the order parameter of the partially coherent vacuum at the same space-time points that the control valve shares with the vacuum. The result for the induced zero point energy density space-time curvature local field at space-time event P coarse-grained over a neighborhood spatial volume $\delta\Omega(P)$ is then of the form of a generalized Bohm-Aharonov-Josephson “weak link” coupling

$$\delta\Lambda_{zpf}(P)\approx\frac{1}{L_p^{*2}}\delta\Omega(P)\sqrt{n_{e^+e^-}(P)}\sqrt{n_{control}(P)}\cos\left(\Theta_{vac}(P)-\Theta_{control}(P)\right) \tag{7.2}$$

Where n denotes the condensate densities. The macro-quantum order parameters are normalized like the single-particle micro-quantum wave functions to $1/\sqrt{Volume}$, but without any assumption of the Born probability density and the von Neumann projection postulate of the orthodox Copenhagen type theory of micro-quantum measurement. The latter is suppressed by what P.W. Anderson calls "generalized phase rigidity" of which $8\pi G/c^4 \sim 10^{-33} cm/10^{19}\, Gev$ ~ (string tension)$^{-1}$ ~ $L_p^{*2}/\hbar c$. For example, if the control is a coherently phased array of tiny rotating high Tc superconducting rings with angular velocity $\vec{\omega}$, we have per real electron pair

$$\cos\left(\Theta_{vac}(P) - \Theta_{control}(P)\right) \sim \cos\left(\frac{2e}{\hbar c}\oint \vec{A}\cdot d\vec{\ell} - \frac{2m_e}{\hbar}\oint \vec{v}\cdot d\vec{\ell}\right) \qquad (7.3)$$

$$\vec{v} \equiv \vec{\omega}\times\vec{r}$$

Some kind of nano-engineered ferromagnetic spintronic mesh may also work as well as other kinds of nano-engineered control systems embedded in the fuselage of an unconventional flying object.

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i Schwarzschild, B. "High-Redshift Supernovae Reveal an Epoch When Cosmic Expansion Was Slowing Down," Physics Today, Search and Discovery, June 2004, 19 – 21.

ii The Poincare group invariant rest mass parameter m ~ 1Mev for lepto-quarks is explained as a spontaneous symmetry breaking vacuum coherence "Higgs mechanism" effect in the parity-violating SU(2) weak force. The hadronic rest masses ~ 10^3Mev come primarily from the kinetic energy of bound quarks according to QCD's "bag model," which I explain here as essentially an exotic vacuum partially cohered zero point energy effect quite similar to the mesoscopic EVOS observed by Ken Shoulders.

iii This procedure is also called "ODLRO" for "Off-Diagonal-Long-Range-Order" in the quantum reduced density matrices or ground state second quantized field correlation functions. The appearance of smooth local ODLRO is a macroscopic eigenvalue N_o in a low order correlation function that is a generalized Bose-Einstein condensate from a ground state instability in the many-particle system. This quantum phase transition is an effective collapse of the volume of phase space of the ground state (or vacuum) which means a lowering of the quantum entropy ~ log of the volume of phase space that allows for the emergence of new forms of collective order.

iv The surface of our rotating Earth is LNIF. Astronauts in free float orbit around the Earth with rockets off and no rotation about the center of mass of the Shuttle or Space Station are LIF. The tetrad map connects locally coincident LIFs with LNIFs at same event P. Different events P and P' are objectively distinguishable if they have different configurations of non-gravity fields in their neighborhoods.

v Note the ubiquitous role of the quantum of area L_p^{*2} in the key formulae for the emergence of Einstein's smooth curved space-time from the cohering of the random zero point vacuum fluctuations, The quantum of area is to Sakharov's "metric elasticity' what the quantum of vorticity/circulation is to macro-quantum superfluid hydrodynamics.

vi It is known in the topology of complex order parameters in soft condensed matter physics that the single component field I use here only allows 1D string topological defects in 3D space. Adding more components to the macro-quantum coherent order allows other kinds of topological defects including point defects and generally "brane" defects whose dimensionalities also depend on how many effective dimensions of the physical space there are. There is also the issue of fractional dimensions and even continuous and complex dimensions that I ignore here because, so far, the important physics do not require these purely mathematical generalizations.

vii J. Bardeen, L.N. Cooper & J.R. Schrieffer, "Microscopic Theory of Superconductivity" Phys. Rev. 106, 162-164 (1957).

viii Virtual photons have positive random incoherent zero point vacuum fluctuation energy density with equal and opposite negative quantum vacuum pressure since w = -1 from covariance, the equivalence principle and the uncertainty principle all acting in concert with each other. Since the gravitational influence of the pressure is three times stronger than the energy density, a pure virtual photon random field will anti-gravitate. Virtual electron-positron unbound pairs in a random incoherent vacuum plasma, that is the "normal fluid" component of the partially coherent physical vacuum, have negative zero point energy density and therefore, again w = -1, have equal and opposite quantum vacuum pressure, that is positive! An isolated random incoherent virtual electron-positron vacuum plasma will gravitate. We must take each polarization-spin state independently. Virtual photons have 3 and virtual electron positron pairs have 2 per quantum. A simple calculation gives a zero point energy density of order $\hbar c/L_p^{*4}$ There is no reason to assume an exact cancellation from all the fields. Supersymmetry models do have such an exact cancellation, but so far there is no real evidence for it and it is badly broken , therefore it cannot explain the cosmological constant paradox.

ix This section follows the work in
F. Lobo, M. Visser, "Fundamental Limitations on Warp Drive space-times" gr-qc 0406083
M. Alcubierre, "The Warp Drive: hyper-fast travel within general relativity" Class. Quantum Grav. 11, L73-L77 (1994)
R. Forward, "Negative Matter Propulsion" J. Propulsion, 6, 28-37, (1990)

x "Gravimagnetic" is used by Ray Chaio in his "gravity radio" transducer using Type II superconductors. However, because of the mixed space-time components and the fact that these terms in the Einstein tensor are first order in (v/c), "gravielectric" would be more fitting. The purely space-space components of the Einstein tensor are second order in (v/c) like magnetic fields.

xi Lower indices with the full curved metric.

xii We start with these baby steps. One must crawl as a worm before metamorphosis to the butterfly.

[xiii] Thanks to Kim Burrafato for bringing the Lobo-Visser paper to my attention.

[xiv] The latter may be a Bohm macro-quantum potential effect.

[xv] Here we ignore possible gauge potential terms that would also require solving the covariant gauge force equations as well in a globally self-consistent bootstrap for the dynamical evolution of possible universes in this large-scale approximation.