# Dynamical Casimir effect and the Big Bang

A quantum cosmological model for the origin of matter, cosmic inflation and gravity


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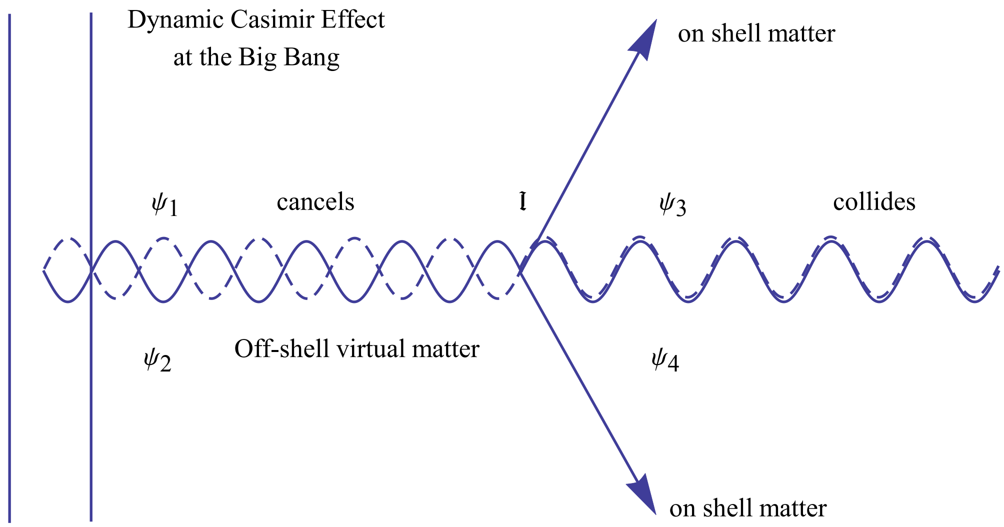


Keywords

Scalar Field, Wheeler's Single Electron Model[1], Big Bang, Feynman-Stückelberg Interpretation[2], Quantum Reflection, Inflation, Hartle-Hawking State[3], Dynamical Casimir Effect, Adiabatic Theorem, Higgs Field, Geometric Phase[4], Origin of Gravity, Newton's First Law, Mach's Principle, Dark Matter, Sakharov Conditions, Flatness Problem, Horizon Problem, Monopole Problem, Vacuum Catastrophe.

Abstract

It is proposed in accordance with the Feynman-Stückelberg Interpretation that out of the quantum vacuum the anti-particles of virtual pairs travel backwards along the axis of Time to reflect off the boundaries of a quantum potential of a scalar field at the start of the universe. The scalar field is subject to quantum fluctuations that adiabatically shift the boundaries of the potential which acts as the moving mirror of the Dynamical Casimir effect. Concomitant with the quantum fluctuations are the production of matter-antimatter pairs. A theorem is proposed, via a mechanism that has its foundation in the Wick Rotation[5], the virtual particles undergo a quantal adiabatic, geometric phase reflection; and as a consequence of the Pauli Exclusion principle this shift in phase nonholonomically conflates virtual particles under Lorentz Invariance into real particles. It is proposed that this model is consistent with the Hartle-Hawking state; leads directly to Guth's Inflationary model[6]; a mechanism for a modified gravitational field (MOND) is given; and finally the results are shown consistent with the Sakharov conditions[7] for the Big Bang.

Contents

## §0 Introduction - Something Out Of Nothing

The greatest problem in physics is to construct a universe out of nothing while maintaining the constancy of physical laws across the timeline of a homogeneous and isotropic universe. While in philosophy the idea of a prime mover or a first cause this seems to be an irremovable problem, in physics our best solution seems to be the Hartle-Hawking state - a no-boundary universe where time has both no beginning and Euclidean space is transformed into time at the Big Bang. This removes the problem of “what came first” to the new problem of “cause and effect” starting with the Big Bang itself, as in the Hartle-Hawking state is no spacetime before the Big Bang just the mathematics of Euclidean space, “cause and effect” belongs to our universe and not to mathematics. By treating our universe as a quantum mechanical system, Hartle-Hawking examined the bound solutions to the ground state over the complete history of the system, proposing a universal wave equation in a minisuperspace (ground state) over a conformally covariant scalar field for the Wheeler-DeWitt second order differential equation under the Schrödinger’s equation. In other words they considered the whole universe as a quantum system and solved for the lowest energy state, and this lead to the proposition that the universe has no boundary since the boundary of Minkowski spacetime disappears at the Big Bang.

Tryon, Vilenkin[8] et al., have extended this idea by postulating the formation of the universe out of quantum fluctuations of an underlying scalar field, and Borde-Guth-Vilenkin were able to show that an expanding universe has no boundary which corresponds to the Hartle-Hawking state. So our best model for the Big Bang suggests a universe which surprisingly has no beginning in time, expands from the fluctuation of the ground state of a singularity, and may expand into the infinitely removed future.

The central idea that allows this transformation from the boundaryless condition is the Wick Rotation, where space is rotated into "time", as Euclidean space becomes Minkowski spacetime. The Wick Rotation has two features, firstly as stated Euclidean space rotates into Minkowskian spacetime, although Hawking describes this transformation in the reverse direction I am presenting, where Minkowski time is rotated into imaginary coordinate of complex space to "imaginary time",

$$\tau = i t$$

The second feature of the Wick Rotation is the inversion of potential, a potential U in Minkowskian spacetime is rotated into Euclidean space,

$$U\left(\mathbb{R}^{1,3}\right) \Longrightarrow - U\left(\mathbb{R}^{4}\right)$$

These two features of the Wick allow the analytic continuation between the Hamiltonian Actions of Euclidean and Minkowski spaces, since it is the Wick rotation that allows the bound solutions to Hartles-Hawking's universal wave equation in a minisuperspace to have no boundary. It needs to be understood that Euclidean space and Minkowski spacetime are not contiguously joined together, rather Minkowski spacetime appears out of nothing, and in a mathematical sense Minkowski spacetime is transformed out of a subset of Euclidean space.

What is lacking from this model is a mechanism for the matter-antimatter asymmetry we observe in our universe, in other words, while we have a mathematical technique that allows us to map from Euclidean space to Minkowski spacetime, we lack a quantum mechanical mechanism to explain the observed existence of matter in Minkowski spacetime and more importantly - where is all the antimatter?

In this paper a mechanism is proposed which has its foundation in the Wick Rotation, the Dynamical Casimir effect and the Geometrical Phase, it does this by first considering the relation of the Hartle-Hawking no boundary proposal to Berry's Geometric Phase in the context of the scalar field - which Vilenkin and others have labelled the Inflaton. To do this requires pulling apart the Inflaton as a dynamic infinite potential well and applying Heisenberg Uncertainty relations to the zero state of the quantum vacuum (Intrinsic Quantum Uncertainty) or the minisuperspace of the Hartle-Hawking model. This immediately leads to a model for the Big Bang and a mechanism for the production of universally identical fermions.

The key feature of this paper is a theorem showing how virtual matter-antimatter pairs are revolved into real on mass-shell matter.

The remainder of the paper is a discussion of Newton's First Law; the Vacuum Catastrophe; a plausible mechanism for the gravitational field; the Flatness and Horizon Problems; the fitness of the model to the Sakharov Conditions; and whether or not matter-antimatter asymmetry is satisfied. A set of tests and predictions are given as necessary experiments to prove or disprove the model I have presented. Finally the results in recent experiments for the dynamical Casimir effect; undetermined sources of extragalactic light; and the lack of monopoles at the Big Bang are suggested as possible evidence of the truth of this model.

§1 Assumptions

It follows from Hubble's Law the universe evolves from an infinitesimal point to the present universe, this point is the boundary of our universe and will be labelled as the singularity $\mathbb{U}_i$, this evolution requires two assumptions,

$$1: \text{ A singularity at point } \mathbb{U}_i \tag{1}$$

$$2: \text{ The Perfect Cosmological Principle holds in the region near } \mathbb{U}_i \tag{2}$$

To construct a model of the Big Bang necessarily includes states of spaces prior to the Big Bang, and while the existence of a singularity precludes physical knowledge of events or states prior to $\mathbb{U}_i$, those states before $\mathbb{U}_i$ are expected to be mathematical, and our physical universe is in some way transformed from this presumably Euclidean space. The Perfect Cosmological Principle states the Universe is homogeneous and isotropic in space and time, so the physics of the Big Bang is the same as our present, since the second assumption proposes the Perfect Cosmological Principle is valid near $\mathbb{U}_i$, this necessarily includes both Euclidean space and Minkowski Spacetime, therefore any dynamical equation must be satisfied in *both* spaces, and the Perfect Cosmological Principle is required *before* the Big Bang.

To satisfy these requirements the simplest possibility divides the universe between a Euclidean space before $\mathbb{U}_i$ and Minkowski Spacetime after $\mathbb{U}_i$, with these two domains continuously connected under the Wick rotation.

$$\mathbb{R}^4 = (X_0, X_1, X_2, X_3) \underset{\longleftrightarrow}{\text{Wick}} \mathbb{R}^{1,3} = (t, x, y, z) \tag{3}$$

By definition Euclidean space is non-relativistic so it is necessary to assume the non-relativistic Schrödinger's equation holds in both domains. This is consistent with the Hartle-Hawking proposal that the ground state of a wave function obeying the Wheeler-DeWitt second order differential equation[9] using the Schrödinger’s equation, -“this is naturally defined by the path integral, made definite by a rotation to Euclidean time, over the class of paths which have vanishing action in the far past.”[3] Continuing on from this, I propose that a solution for the wave function of the Schrödinger's equation across the domains from Euclidean space to Minkowski Spacetime via the Wick rotation is required for *continuity between the domains* - it is not enough there be a solution in our domain, the solution must exist in both domains.

§2 The Relation of the Hartle-Hawking no boundary proposal to Berry's Geometric Phase

§2-1 Hartle-Hawking state

Hartle-Hawking[3] proposed using Everett's [10] Universal Wave Function Ψ(x,t) in the context of a state of minimum excitation of Schrödinger equation for the state of the universe,

"*A state of particular interest in any quantum-mechanical theory, is the ground state, or state of minimum excitation. This is naturally defined by the path integral, made definite by a rotation to Euclidean time, over the class of paths which have vanishing action in the far past. Thus for the ground state at t = 0 one would write*,

$$\Psi_0\,(x,\,0)\;=\int \mathrm{dx}(\tau)\,e^{+\frac{1}{\hbar}S_E[x(\tau)]} \tag{4}$$

*Where* $S_E[\mathrm{x}(\tau)]$ *is the Euclidean action obtained from S by rotation sending* t → -$i\tau$ *and adjusting the sign so that it is positive*."

The phrase -"*This is naturally defined by the path integral, made definite by a rotation to Euclidean time, over the class of paths which have vanishing action in the far past*."- is reference to the Wick Rotation[5] and effectively it states that in the remote past before the Big Bang we are dealing with a Euclidean space, and the question arises how does the physics of the Big Bang evolve from pure Euclidean space. To examine this I will first describe the general relation of Euclidean space to Minkowski Spacetime, then examine the Hamiltonians and Lagrangians that evolve from that general relation, and give finally a general solution to the Hartle-Hawking state.

The Minkowski $\mathbb{R}^{1,3}$ Spacetime has a (-1,1,1,1) metric signature while Euclidean $\mathbb{R}^4$ space has (1,1,1,1), and Minkowski Spacetime $\mathbb{R}^{1,3}$ transforms to Euclidean space $\mathbb{R}^4$ under the Wick rotation,

$$\mathbb{R}^4 = (X_0, X_1, X_2, X_3) \underset{\Longleftrightarrow}{\text{Wick}} \mathbb{R}^{1,3} = (T, X, Y, Z) \tag{5}$$

Euclidean space is subject to the Euclidean group E(n), while Minkowski Spacetime is subject to the Poincaré group, both are subgroups of the Affine group, and it is possible to transform from the Affine space, to Euclidean space then to Minkowski Spacetime. Minkowski space is a pseudo-Euclidean space and it is flat only in the absence of energy, while by definition the curvature of Euclidean space is flat.

Equating the norms of the metrics

$$dx_0^2 + dx_1^2 + dx_2^2 + dx_3^2 \geq -dt^2 + dx^2 + dy^2 + dz^2 \tag{6}$$

It can be seen the Euclidean metric is a many-to-one or surjective function to the Minkowski metric, consequently, if $\Omega$ is the set of particles for each point in $\mathbb{R}^4$ were to tunnel to $\mathbb{R}^{1,3}$, there must be subsets of $\Omega$ which share the same points in $\mathbb{R}^{1,3}$. If at each point in $\mathbb{R}^4$ and $\mathbb{R}^{1,3}$ there are a set of corresponding quantum states $\Omega$, then particles can tunnel between $\mathbb{R}^4$ and $\mathbb{R}^{1,3}$, and while for bosons there would be no conflict, for fermions there must subsets of $\Omega$ that necessarily violate the Pauli Exclusion principle, and this violation will be of considerable importance later in this paper.

The Euclidean potential $V_E\left(\mathbb{R}^4\right)$ is a negative semidefinite transformation of the Minkowski potential $V_M\left(\mathbb{R}^{1,3}\right)$ under the Wick Rotation,

$$V_E\left(\mathbb{R}^4\right) \geq 0 \quad \underset{\Longleftrightarrow}{\text{Wick}} \quad -V_M\left(\mathbb{R}^{1,3}\right) \leq 0 \tag{7}$$

In the neighbourhood of the Big Bang with limit as t → 0, take the path integral formulation of the Minkowski Hamiltonian $\mathcal{H}_M$ written in terms of the dynamic variables kinetic energy T and potential energy V,

$$\mathcal{H}_M\left(\mathbb{R}^{1,3}\right) = T + V > 0 \tag{8}$$

Compared to the $\mathbb{R}^4$ Euclidean Hamiltonian with the geometric equivalent of kinetic energy $\mathbb{T}$ and potential energy $\mathbb{U}$, the problem of how a particle could exist in $\mathbb{R}^4$ is solved by assuming zero mass, zero charge and zero spin, so a wave equation and nothing more.

$$\mathcal{H}_E\left(\mathbb{R}^4\right) = \mathbb{T} - \mathbb{U} = 0 \tag{9}$$

Obviously the total energies do not match.

$$\mathcal{H}_M\left(\mathbb{R}^{1,3}\right) \geqslant \mathcal{H}_E\left(\mathbb{R}^4\right) \tag{10}$$

Similarly in comparing the Euclidean Lagrangian $\mathcal{L}_E$ to the Minkowski Lagrangian $\mathcal{L}_M$ via the Wick rotation,

$$\mathcal{L}_E\left(\mathbb{R}^4\right) = \mathbb{T} + \mathbb{U} \geq 0 \tag{11}$$

$$\mathcal{L}_M\left(\mathbb{R}^{1,3}\right) = T - V = 0 \tag{12}$$

$\mathcal{L}_E$ is ordered positive semidefinite to $\mathcal{L}_M$,

$$\left|\mathcal{L}_E\left(\mathbb{R}^4\right)\right| \geq \left|\mathcal{L}_M\left(\mathbb{R}^{1,3}\right)\right| \tag{13}$$

It can also be seen the Lagrangians do not match, therefore the Hamiltonian Actions derived from the Lagrangians do not match. To match the Hamiltonians of $\mathbb{R}^4$ to $\mathbb{R}^{1,3}$ requires an additional potential be subtracted from $\mathbb{R}^{1,3}$, and the obvious field is gravity $G$,

$$\mathcal{H}_M\left(\mathbb{R}^{1,3}\right) = T + V - G = 0 \tag{14}$$

so along with the other potentials V for Electro-Weak and Strong, the gravitational potential appears as an extra geometric term to maintain Euclidean flatness.

To insure continuity under the Wick transformation from $\mathbb{R}^4$ to $\mathbb{R}^{1,3}$ I require the actions map under the Wick transformation. As Hartle-Hawking pointed out the Euclidean action vanishes in the far past by sending the initial boundary of $\mathbb{R}^4$ to -infinity (or the far past)

$$\int_{-\infty}^{\lim\limits_{X_0 \to \mathbb{U}_\mathrm{i}}} \mathrm{dx}(X_0)\, e^{+\frac{1}{\hbar} S_E[X_0]} \underset{\Longleftrightarrow}{\text{Wick}} \int_{\lim\limits_{t \to \mathbb{U}_\mathrm{i}}}^{t} \mathrm{dx}(t)\, e^{-\frac{i}{\hbar} S_M[x(t)]} \tag{15}$$

The problem is to show how in the neighbourhood of the Big Bang with limit as $t \to \mathbb{U}_\mathrm{i}$ as $\mathbb{R}^4$ transforms into $\mathbb{R}^{1,3}$ the universe picks up additional energy in the form of mass and charge, to do this I first need to examine in detail the Hartle-Hawking no boundary proposal in context of a scalar field.

## §2-2 A Mechanism for the Perfect Cosmological Principle and the Hartle-Hawking no boundary proposal

Writing the Euclidean Hamiltonian as a function of a scalar field and allowing the total energy of

Euclidean space to be zero, where the dynamical variables momentum and energy are dimensionless in $\mathbb{R}^4$, and accordingly any wave equation is a purely mathematical object.

$$\mathcal{H}_E(\phi) = \mathbb{T}(\phi) - \mathbb{U}(\phi) = 0 \tag{16}$$

Here $\mathbb{U}(\phi)$ is the geometric potential for the entire universe of $\mathbb{R}^4$, and since $\mathbb{R}^{1,3}$ is a subspace of $\mathbb{R}^4$ any global change in $\mathbb{U}(\phi)$ causes a global change in $\mathbb{R}^{1,3}$. Under the premise that nothing existed before the Big Bang at $\mathbb{U}_\mathrm{i}$ , then matter is absent in $\mathbb{R}^{1,3}$ and the dynamical variables $T,V$ are zero,

$$\mathcal{H}_M\left(\mathbb{R}^{1,3}\right) = T + V - G = 0 \tag{17}$$

$$T = V = G = 0 \tag{18}$$

Therefore initially $\mathbb{R}^{1,3}$ is as flat as $\mathbb{R}^4$. Since $\mathcal{H}_E(\phi) = 0$, this implies -and most importantly - there is no center or boundaries to $\mathbb{U}$, for as the momentum and energy tends to zero so the Heisenberg uncertainties in position and time also tend to infinity,

$$\delta\mathrm{T} \geq \lim_{\delta\mathrm{E} \to 0} \frac{\hbar}{2\,\delta\mathrm{E}} \to \infty \tag{19}$$

$$\delta\mathrm{X}_i \geq \lim_{\delta\mathrm{P}_i \to 0} \frac{\hbar}{2\,\delta\mathrm{P}_i} \to \infty \tag{20}$$

$$X_i \simeq X_i \pm \delta\mathrm{X}_i \simeq X_i \pm \infty \tag{21}$$

So the boundary to any point is at infinity, which is a restatement of the Hartle-Hawking no boundary proposal.

Yet adding the maximal uncertainty to the boundary itself,

$$X_i \simeq X_{\max} \pm \delta\mathrm{X}_{\max} \tag{22}$$

implies the boundary simultaneously coincides with every other point within this model universe and has the remarkable result that *every point within the potential behaves as a boundary of the potential*.

In effect, at $\mathbb{U}_i$ where starting from a homogeneous and isotropic $\mathbb{R}^4$ and then applying the Heisenberg Uncertainty principle to $\mathcal{H}_E$ as $\mathbb{R}^4$ evolves smoothly under the Wick Transformation into $\mathbb{R}^{1,3}$ to the $\mathcal{H}_M$; results in every point in $\mathbb{R}^{1,3}$ being bounded and adjacent to every other point in $\mathbb{R}^{1,3}$, therefore at the Big Bang every point in $\mathbb{R}^{1,3}$ is homogeneous and isotropically identical to every other point which is of course the Perfect Cosmological Principle [11].

The maximal uncertainty in the position of the boundary also places each point $x_i$ at infinity, this contradiction is resolved by noting the statistical nature of Heisenberg's Uncertainty principle, it follows that any particles reflecting off the boundary do so with a statistical expectation and therefore the boundary has a probability of position - the boundary is simultaneously at infinity and every point within the potential. This is a generalization of the Hartle-Hawking no boundary proposal, strictly speaking the uncertainty in the boundary has it everywhere as opposed to placing the boundary at infinity, accordingly I call this the generalized Hartle-Hawking no boundary proposal (gHH).

$$\text{Hartle} - \text{Hawking proposal } X_i \to (\infty) \tag{23}$$

$$\text{generalized Hartle} - \text{Hawking proposal } X_i \to (0, \infty) \tag{24}$$

To derive the Perfect Cosmological Principle it is necessary to note Hartle-Hawking's statement the ground state of a wave function "- is naturally defined by the path integral, made definite by a rotation to Euclidean time, over the class of paths which have vanishing action in the far past."[3]

The dual of this statement which is necessary in the context of the gHH, is that the path integral has *non-vanishing action* in the remote past, and this is easy to show where the action is derived from the $\mathcal{L}_E$,

$$S_{\text{Euclidean}}(\phi) = \int_{t_1}^{t_2} \mathcal{L}_E\left(\phi(t), \dot{\boldsymbol{\phi}}(t), t\right) dt = \int_{t_1}^{t_2} \mathbb{T}(\phi) + \mathbb{U}(\phi)\, dt \geq 0 \tag{25}$$

integrating the Euclidean Lagrangian from geometric infinity to the initial point of the Big Bang at $\mathbb{U}_\text{i}$,

$$S_{\text{Euclidean}}(\phi) = \int_{-\infty}^{\mathbb{U}_\text{i}} \mathbb{T}(\phi) + \mathbb{U}(\phi)\, dt \geq 0 \tag{26}$$

Therefore the action is non-vanishing,

$$\frac{\delta \text{S}}{\delta \text{q}(t)} \geq 0 \tag{27}$$

Since the position of the boundary is now statistical, and can be at both infinity and the zero at $\mathbb{U}_\text{i}$, I can now treat the boundary as arbitrary so $\mathbb{R}^4$ is now a open and a closed universe.

Noting $\mathbb{R}^{1,3}$ is a subspace of $\mathbb{R}^4$ and the norms of the metrics,

$$\text{dx}_0{}^2 + \text{dx}_1{}^2 + \text{dx}_2{}^2 + \text{dx}_3{}^2 \geq -\text{d}\tau^2 + \text{dx}^2 + \text{dy}^2 + \text{dz}^2 \tag{28}$$

This puts a boundary around every point in $\mathbb{R}^{1,3}$ and it follows that $\mathbb{R}^{1,3}$ is a closed universe, this is only possible if the total energy is zero, which is possible by the introduction of gravity as Hartle-Hawking put it - “Indeed in a certain sense the total energy for a closed universe is always zero - the gravitational energy cancelling the matter energy.”[3]

In which case, the Minkowskian Hamiltonian requires the addition of an extra potential for Gravity

$$\mathcal{H}_M\left(\mathbb{R}^{1,3}\right) = T - G = 0 \tag{29}$$

If this Hamiltonian is expanded to include terms for the Electro-Weak and Strong potentials

$$\mathcal{H}_M\left(\mathbb{R}^{1,3}\right) = T + V - G = 0 \tag{30}$$

Then the total energy is still zero as the Electro-Weak and Strong potentials require equal and opposite charges to satisfy conservation of charge and their internal fields sum to zero, leaving only Gravity as the dominant potential, this is readily evident by looking out the window seeing that Gravity is the dominant potential on a global scale; and this allows me to write for the universe where $\phi$ is some field extant from $\mathbb{R}^4$ to $\mathbb{R}^{1,3}$,

$$\mathcal{H}_E(\phi) = \mathcal{H}_M(\phi) = 0 \tag{31}$$

It is now possible to match the actions of $\mathbb{R}^4$ to $\mathbb{R}^{1,3}$ which in turn allows continuity of the Universal Wavefunctions

$$\int_{-\infty}^{\lim_{X_0 \to \mathbb{U}_i}} dx(X_0)\, e^{+\frac{1}{\hbar} S_E[X_0]} \underset{\Longleftrightarrow}{\text{Wick}} \int_{\lim_{t \to \mathbb{U}_i}}^{t} dx(t)\, e^{-\frac{i}{\hbar} S_M[x(t)]} \tag{32}$$

So starting from the observation that the total energy of $\mathbb{R}^4$ must match the total energy of $\mathbb{R}^{1,3}$ and the Heisenberg's uncertainty principle, it is possible to derive the generalized Hartle-Hawking no boundary proposal, and this leads to continuity of the minimum excitation of Schrödinger equation from $\mathbb{R}^4$ to $\mathbb{R}^{1,3}$ which identical to the premise that Hartle and Hawking originally put forward.

This working is not a proof of the Perfect Cosmological Principle for that was taken as an fundamental assumption, and I could have easily started off with only the Wick Transformation, the New Hamiltonian and the Heisenberg uncertainty principle then derived the above without much difficulty, but I felt it neccessary to start off from the conventional model to derive the above, to paraphrase Poincaré *echafaudage est nécessaire de construire la maison de la science, mais il faut retirer l'échafaudage pour voir la pierre,* so this working is a justification of using the second fundamental assumption and not a proof.

§2-3 A Derivation of Berry's Geometric Phase from the Geometric Potential

It is now possible to examine the behavior of the potential as a whole by examining a mechanism for the global phase $\gamma$,

$$\phi \to e^{i\gamma}\,\phi \tag{33}$$

First the new Lagrangian for Euclidean space,

$$\mathcal{L}_O = \mathbb{T}(\phi) + \mathbb{U}(\phi) \tag{34}$$

results in a new action $S_O$ for $\mathbb{R}^4$,

$$S_O = \int \mathcal{L}_O \,\mathrm{dt} = \int \mathbb{T}(\phi) + \mathbb{U}(\phi) \quad dt \tag{35}$$

for the ground state of $\mathbb{U}(\phi)$ the kinetic term tends to zero, allowing the geometric phase to be determined in terms of $\mathbb{U}(\phi)$,

$$e^{i\,\gamma(t)} = e^{i\int \mathbb{U}\,(\phi)\,\mathrm{dt}} \tag{36}$$

Taking time t as an independent variable, this phase successively becomes,

$$\int \mathbb{U}\ \mathrm{dt} = -\int -\mathbb{U}\ \mathrm{dt} = -\iint\left(-\frac{\partial \mathbb{U}}{\partial x}\right)\mathrm{dt\,dx} \tag{37}$$

By Ehrenfest's Theorem[13] and taking $\mathbb{P}$ as the geometric equivalent of momentum in the same way as $\mathbb{T}$ is the geometric equivalent of kinetic energy,

$$\frac{d\,\langle\mathbb{P}\rangle}{\mathrm{dt}} = \left\langle -\frac{\partial\mathbb{U}}{\partial x}\right\rangle \tag{38}$$

$$-\int\!\!\int\left(-\frac{\partial\mathbb{U}}{\partial x}\right)\mathrm{dt}\,\mathrm{dx} = -\int\frac{d\,\langle\mathbb{P}\rangle}{\mathrm{dt}}\,\mathrm{dt}\,\mathrm{dx} = -\int\langle\mathbb{P}\rangle\cdot dx \tag{39}$$

Substitute the momentum operator for the n’th level of the infinite square potential in the vicinity of $\mathbb{U}_{\mathrm{i}}$, even though $\hbar$ is dimensionless in $\mathbb{R}^4$ it is included for completeness,

$$\int\mathbb{U}\;\mathrm{dt} = -\int\langle\mathbb{P}\rangle\cdot dx = -\frac{\hbar}{i}\int\!\!\int\psi_n^*\,\frac{\partial}{\partial x}\,\psi_n\,\mathrm{dx}\cdot dx \tag{40}$$

Simplify and use the Dirac notation,

$$\int\mathbb{U}\;\mathrm{dt} = \hbar\, i\int\langle\psi_n\,|\nabla_x|\,\psi_n\rangle\cdot dx \tag{41}$$

to determine the phase $\gamma$ of the integral $\int\mathbb{U}\;\mathrm{dt}$ divide by $\hbar$ and the $\hbar$ drops out, then integrate over all space,

$$\gamma_n(t) = i\int\langle\psi_n\,|\nabla_R|\,\psi_n\rangle\cdot dR \tag{42}$$

exponentiate,

$$e^{i\,\gamma_n(t)} = e^{i\,i\int\langle\psi_n\,|\nabla_R|\,\psi_n\rangle\cdot dR} \tag{43}$$

so the phase is real,

$$i\,\gamma\in\mathcal{R} \tag{44}$$

giving the wavefunction in terms of a geometric phase,

$$\Psi = \int\mathrm{dx}\,\Psi_0\,e^{i\,\gamma} \tag{45}$$

the extra term applies globally to the potential $\mathbb{U}$ as $\Psi$ evolves, this is equivalent to a global geometric phase change $\gamma$,

$$\phi \to e^{i\gamma}\phi \tag{46}$$

Since this is a global phase change I expect it to apply in both $\mathbb{R}^4$ and $\mathbb{R}^{1,3}$, returning to the new Lagrangian $\mathcal{L}_M$ to include the dynamic phase $e^{\int \mathcal{L}\,\mathrm{dt}}$,

$$e^{\int \mathcal{L}_M\,\mathrm{dt}} = e^{\int \mathbb{U}(\phi)\,\mathrm{dt}}\, e^{\int \mathcal{L}\,\mathrm{dt}} = e^{i\,\gamma(t)}\, e^{-i\,\theta(t)} = e^{i[\gamma(t)-\theta(t)]} \tag{47}$$

and finally the universal wave function can be written,

$$\Psi = \int \mathrm{dx}\,\Psi_0\, e^{i[\gamma(t)-\theta(t)]} \tag{48}$$

It can be seen that integrating the new potential over time is identical to Berry's Geometric Phase factor from his work on the Adiabatic Theorem[4], where he showed from the geometrical properties of the parameter space the Hamiltonian of a cyclic quantal adiabatic process will acquire an additional phase $\gamma(\mathrm{C})$. This can be generalized by writing for a Hamiltonian $\hat{\mathcal{H}}(\mathrm{X(T)})$ on a parameter space $\mathbf{R} = (\mathrm{X,Y,Z...})$, where C is the circuit over R(T) = R(0), and quantal adiabatic limit $\mathrm{T} \to \infty$. Since the natural basis of discrete eigenstates under the Schrodinger equation with energies $E_n(\mathrm{X})$ is,

$$\hat{\mathcal{H}}(\boldsymbol{R}(t))\,\big|\,n(\boldsymbol{R})\big\rangle = E_n(\boldsymbol{R})\,|\,n(\boldsymbol{R})\big\rangle \tag{49}$$

with dynamic phase,

$$\theta(T) = -\frac{i}{\hbar}\int_0^T \mathrm{dt}\,E_n(\boldsymbol{R}(t)) \tag{50}$$

and geometric phase over a closed cycle C,

$$\gamma_n(C) = i \oint \langle \psi_n \mid \nabla_{\boldsymbol{R}} \mid \psi_n \rangle \cdot d\boldsymbol{R} \tag{51}$$

where Minkowski Spacetime is assumed to be a continuously transformable from Euclidean space and noting the geometric phase is a pure number, it is now possible without loss of generality to use the geometric phase as an additional factor of the wave function in $\mathbb{R}^{1,3}$ as it affects all points in $\mathbb{R}^{1,3}$ equally, allowing,

$$\mid \psi(T) \rangle_{\mathbb{U}_i} = e^{i[\gamma(C) - \theta(T)]} \left| \psi(T(0)) \right\rangle \tag{52}$$

The idea that the dynamic phase disappears in the Euclidean domain is consistent with the idea the physical universe having a beginning in Time, where transforming from Euclidean space to Minkowski Spacetime under the Wick rotation at $\mathbb{U}_i$ is equivalent to the switching from a geometric system to a dynamic system, which is essentially the idea behind the Hartle-Hawking no boundary proposal, so remarkably the ideas of Hartle-Hawking and Berry can be combined into a single model.

Importantly this transformation is only possible for a cyclic space in its lowest energy level, and this will be of crucial importance in the construction of a Big Bang model to be addressed later in this paper, - very importantly this additional phase factor in $\mathbb{R}^{1,3}$ is homogeneous and isotropic and affects all particles equally and this crucial idea will be returned to in the section on Newton's First Law.

§2-4 Deriving a Universal Wave Equation regulated by the Adiabatic Theorem

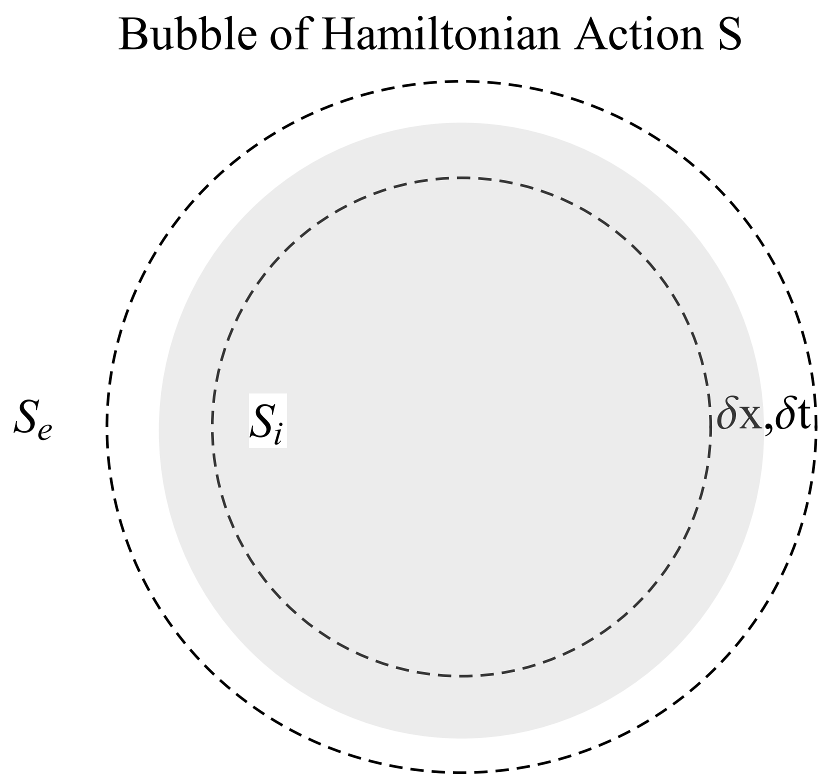
Having shown that Berry's geometric phase can derived from the geometric potential, I require an adiabatic form of the universal wave equation over the Wick divide. Since, as was pointed out above, $\mathcal{H}_E(\phi) = 0$, this implies that as the momentum and energy tends to zero the system can be treated adiabatically. By the Hartle-Hawking's proposal I also require the evolution of the wave equation depends on the path taken and therefore the system is nonholonomic.

To do this I'm first going to apply Ed Tryon's idea of the universe deriving from a quantum fluctuation [14] for the entire universe to an infinitesimal quantum fluctuation at each point in Spacetime, with $s_\alpha$ the action at each point. So the universe is comprised of an infinite sea of bubbles of action, the sum of which is the total action of the universe.

$$S = \sum_{\alpha=1}^{\infty} s_\alpha \tag{53}$$

Make a distinction between an interior surface and exterior surface of the bubble, where the interior surface is determined by the internal action $S_i$ and exterior surface by the external action $S_e$, if the spacetime distance between the two surfaces is zero then,

$$S_i = S_e \tag{54}$$




By conservation of energy - the energy of the internal surface is equal to the energy of the external surface,

$$E_i = E_e \tag{56}$$

so the action can vary proportional to fluctuations in the internal and external periods,

$$\frac{S_i}{S_e} = \frac{E_i\,\delta \mathrm{T}_i}{E_e\,\delta \mathrm{T}_e} = \frac{\delta \mathrm{T}_i}{\delta \mathrm{T}_e} \tag{57}$$

For a slow fluctuation this reduces to the form of the adiabatic parameter $\epsilon$,

$$\epsilon = \frac{S_i}{S_e} = \frac{E_i\,T_i}{E_e\,T_e} = \frac{T_i}{T_e} \tag{58}$$

Importantly the ratio of periods is identical to the ratio of radii assuming Lorentz invariance holds,

$$\epsilon = \frac{T_i}{T_e} = \frac{\omega_e}{\omega_i} = \frac{c}{\lambda_e}\frac{\lambda_i}{c} = \frac{\lambda_i}{\lambda_e} = \frac{R_i}{R_e} \tag{59}$$

In which case the system can be treated nonholonomically as the fluctuation depends on the path taken.

Similarly for conservation of momentum - the momentum of the internal surface is equal to the momentum of the external surface,

$$\mathbb{P}_i = \mathbb{P}_e \tag{60}$$

$$\epsilon = \frac{S_i}{S_e} = \frac{\mathbb{P}_i X_i}{\mathbb{P}_e X_e} = \frac{R_i}{R_e} \tag{61}$$

For static universe (one without fluctuations),

$$S_i = S_e \Rightarrow \epsilon = 1 \tag{62}$$

For a large fluctuation,

$$S_e \to \infty \Rightarrow \epsilon \to 0 \tag{63}$$

For the peculiar state of a quantum fluctuation where the interior radius is outside the exterior radius,

$$R_i > R_e \Rightarrow 0 < \epsilon < 1 \tag{64}$$

The bubble of action can be described as a quantum field with the universal wave function,

$$\Psi = \epsilon \sum_{m\,n} c_{m\,n}\,\psi_{m\,n} = 0 \tag{65}$$

$$\Psi = \epsilon \begin{pmatrix} c_{11}\,\psi_{11} & c_{12}\,\psi_{12} & . & c_{1\,m}\,\psi_{1\,m} \\ c_{21}\,\psi_{21} & c_{22}\,\psi_{22} & . & . \\ . & . & . & . \\ c_{n\,1}\,\psi_{n\,1} & . & . & c_{n\,m}\,\psi_{n\,m} \end{pmatrix} \tag{66}$$

This can be separated into real (on-axis) and virtual (off-axis) parts,

$$\Psi = \epsilon \begin{pmatrix} c_{11}\,\psi_{11} & 0 & . & 0 \\ 0 & c_{22}\,\psi_{22} & . & . \\ . & . & . & . \\ 0 & . & . & c_{n\,n}\,\psi_{n\,n} \end{pmatrix}_{\text{real term}} + \epsilon \begin{pmatrix} 0 & c_{12}\,\psi_{12} & . & c_{1\,m}\,\psi_{1\,m} \\ c_{21}\,\psi_{21} & 0 & . & . \\ . & . & . & . \\ c_{m\,1}\,\psi_{m\,1} & . & . & 0 \end{pmatrix}_{\text{virtual term}} \tag{67}$$

If the wave function is nonholonomic this can be expressed by Berry's version of Fock and Born's Adiabatic Theorem[15],

$$\Psi = \sum_{m=n} c_n\,\psi_n\,e^{i(\gamma-\theta)} + \epsilon \sum_{m \neq n} c_m\,\psi_m \tag{68}$$

with the geometric phase given by,

$$\gamma_n(t) = i \int \langle \psi_n \,|\nabla_R|\, \psi_n \rangle \cdot dR \tag{69}$$

For rapidly evolving dynamics where $\epsilon$ is parametrized by R or T, which is the case if the space is thermalized as in a hot gas,

$$\text{IF} \quad (T_e \to \infty) \quad \text{OR} \quad (R_e \to \infty) \Rightarrow (\epsilon = 0) \tag{70}$$

In which case,

$$\gamma \to 0 \tag{71}$$

and after the big bang as the universe thermalizes this reduces to the holonomic wave equation normally used in quantum mechanics,

$$\Psi = \sum_n c_n\,\psi_n\,e^{-i\,\theta} \tag{72}$$

Treating the exact universal wave equation as a perfect fluid and positing the stress-energy tensor exists at each point in $\Psi(R^{1,3})$, then separating both $T_{\mu\upsilon}$ and into real and virtual parts,

$$T_{\mu\upsilon} = T^{(M)}_{\mu\upsilon} + T^{(V)}_{\mu\upsilon} \tag{73}$$

this has the quantum expectation,

$$\langle \Psi | T_{\mu\upsilon} | \Psi \rangle = \langle \psi_{ij} | T_{\mu\upsilon} | \psi_{ij} \rangle = \langle \psi_{ij} | T^{(M)}_{\mu\upsilon} | \psi_{ij} \rangle + \langle \psi_{ij} | T^{(V)}_{\mu\upsilon} | \psi_{ij} \rangle \tag{74}$$

express this in terms of the Adiabatic Theorem and include the adiabatic parameter,

$$\begin{gathered} \langle \psi_{mn} | T_{\mu\upsilon} | \psi_{mn} \rangle = \\ \left\langle \psi_n(x,\, t)\, e^{i(\gamma(t) - \theta(t))} \left| T^{(M)}_{\mu\upsilon} \right| \psi_n(x,\, t)\, e^{i(\gamma(t) - \theta(t))} \right\rangle_{m=n} + \langle \epsilon\psi_{mn} | T^{(V)}_{\mu\upsilon} | \epsilon\psi_{mn} \rangle_{m \neq n} \end{gathered} \tag{75}$$

moving the adiabatic parameter out of the off-axis matrix,

$$\begin{gathered} \langle \psi_{mn} | T_{\mu\upsilon} | \psi_{mn} \rangle = \\ \left\langle \psi_n(x,\, t)\, e^{i(\gamma(t) - \theta(t))} \left| T^{(M)}_{\mu\upsilon} \right| \psi_n(x,\, t)\, e^{i(\gamma(t) - \theta(t))} \right\rangle_{m=n} + \epsilon^2 \langle \psi_{mn} | T^{(V)}_{\mu\upsilon} | \psi_{mn} \rangle_{m \neq n} \end{gathered} \tag{76}$$

In the adiabatic limit as $\epsilon \to 0$ this reduces to the expectation for matter to,

$$\langle \psi_{mn} | T_{\mu\upsilon} | \psi_{mn} \rangle = \left\langle \psi_n(x,\, t)\, e^{i(\gamma(t) - \theta(t))} \left| T^{(M)}_{\mu\upsilon} \right| \psi_n(x,\, t)\, e^{i(\gamma(t) - \theta(t))} \right\rangle_{m=n} \tag{77}$$

for the non-adiabatic evolution of the wave equation $\gamma \to 0$, reduces the above to the standard energy expectation for a wave equation,

$$\langle \Psi | T_{\mu\upsilon} | \Psi \rangle = \left\langle \psi_n(x,\, t)\, e^{-i\,\theta(t)} \left| T^{(M)}_{\mu\upsilon} \right| \psi_n(x,\, t)\, e^{-i\,\theta(t)} \right\rangle_{m=n} \tag{78}$$

Whereas for the opposite case in the absence of matter, such that $\epsilon > 0$,

$$\langle \Psi | T_{\mu\upsilon} | \Psi \rangle = \epsilon^2 \langle \psi_{mn} | T^{(V)}_{\mu\upsilon} | \psi_{mn} \rangle_{m \neq n} \tag{79}$$

It can be seen the adiabatic parameter <u>regularizes</u> the quantum vacuum and provides a solution to the problem of <u>renormalization</u> in quantum field theory, where Renormalization imposes a constraint between parameters for large distance scales to parameters for small distances. In this model $\epsilon$ acts as a running coupling between the geometry of Spacetime and the wave functions that comprise the Quantum Vacuum.

This leads me to suggest that Berry's form of Fock and Born's Adiabatic Theorem is the correct wave equation for describing quantum systems and including the Big Bang.

## §3 Dynamic Infinite Potential Well and Intrinsic Quantum Uncertainty

By using the Heisenberg Uncertainty principle and Berry's Geometric phase I am going to construct a Bose-Einstein condensate in the form of a Dynamic Infinite Potential Well that undergoes fluctuations in space and time, and this will lead to a mechanism for Adiabatic Inflation of the early universe.

### §3-1 Infinite Potential Well

First some preliminary notes, the ground state $|0\rangle$ of a conventional infinite potential well with n = 1, L is width of well, m is mass, has several neat features,

0: there is no zero state as that violates the Heisenberg uncertainty principle,

1: the energy is defined,

$$E_n = \frac{n^2 \pi^2 \hbar^2}{8 m L^2} \tag{80}$$

2: a particle within the bounds is completely free,

3: a particle evolves as a simple harmonic oscillator,

4: the ground state (or vacuum state) is the lowest possible energy (or zero-point energy),

5: the kinetic energy of the ground state is at a minimum when $L \to \infty$,

6: the ground state is a squeezed coherent state, or the uncertainty principle is saturated,

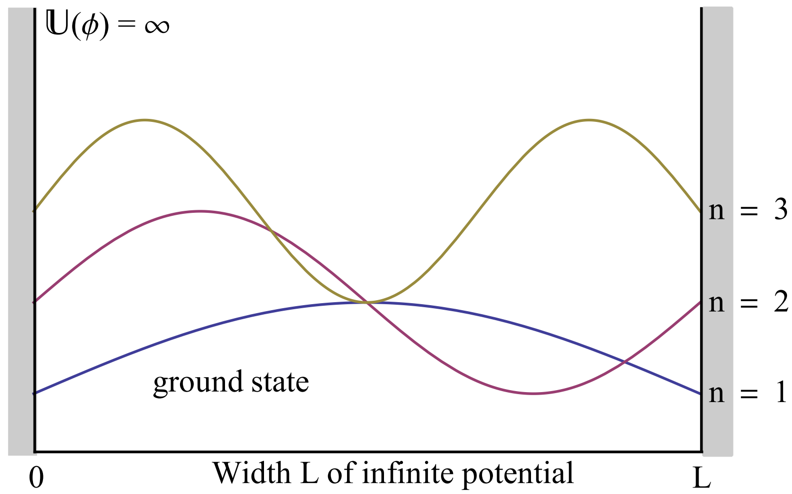
$$\sigma_p \cdot \sigma_x = \frac{\hbar}{2} \tag{81}$$

7: the ground state is an even quadratic function,

8: the ground state has a Gaussian distribution,

$\mathbb{U}(\phi)$ has the form of an infinite square potential, with energy levels $E_n$, n is the principal quantum number, and L is the width of the potential,

$$\mathbb{U}(\phi) = \begin{cases} 0, & \text{if } 0 \leqslant x \leqslant L \\ \infty, & \text{outside} \end{cases} \tag{82}$$

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§3-2 Boundaries of an Infinite Potential Well

An infinite potential well has the Hamiltonian of a closed dynamical system, where the phase space evolves cyclically in time and space. The dimensions $X_i$ of $\mathbb{U}(\phi)$ can be written in terms of the mean values $X_i(0)$ and the uncertainties give by the Heisenberg uncertainty principle,

$$X_i = X_i(0) \pm \frac{\hbar}{2\,\delta P_i} \tag{83}$$

this also applies to the axis of time,

$$T = X_0(0) \pm \frac{\hbar}{2\,\delta E_i} \tag{84}$$

Heisenberg's momentum-space uncertainty principle requires the width or maximal bound of this Hamiltonian tends to infinity, for as the kinetic energy tends to zero so the momentum tend to zero,

$$\overset{\lim}{\delta P_i \to 0} \frac{\hbar}{2\,\delta P_i} = \infty \Rightarrow \delta X_i \to \infty \Rightarrow X_i \to \infty \tag{85}$$

Equally the width or maximal bound of the temporal dimension time, tends to infinity under Heisenberg's energy-time uncertainty principle

$$\lim_{\delta E_i \to 0} \frac{\hbar}{2\,\delta E_i} = \infty \Rightarrow \delta t \to \infty \Rightarrow t \to \infty \tag{86}$$

and this requires that a Euclidean space subject to a Hamiltonian with zero total energy be spatially infinite, this infinity is of great importance in the determination of evolution of the universal wave equation.

Conventionally the width L is treated as either static or moving with a fixed velocity in the context of the Dynamical Casimir Effect[16]. I propose the sides of the potential to have a variable width that moves back and forth according to the Heisenberg's uncertainty principle, so the volume of the potential as a four dimensional sphere undergoes fluctuations. Which in its most general form can be seen as a bubble of Hamiltonian action that wobbles about in space and time, as both the actual dimensions and the energy levels are modulated by Heisenberg's uncertainty principle, and since the uncertainty is cyclic then the boundaries of $X_i$ move back and forth as the system evolves through its phase space - this is the Dynamic Infinite Potential Well.

§3-3 The ground state of a Dynamic Infinite Potential Well as a Bose-Einstein condensate (BEC)

The Euclidean potential $\mathbb{U}(\phi)$ of the chargeless and spinless boson leads to a boson gas for the Higgs boson, noting the Bose-Einstein distribution,

$$n(\epsilon) = \frac{1}{e^{(\epsilon - \mu)/k_B T} - 1} \tag{87}$$

where the chemical potential $\mu$ for a boson is zero, and if the temperature is zero, this has the proposition

$$n(\epsilon) = \infty \tag{88}$$

In other words, the ground state of the Higgs potential with no coupling between the particles has an infinite number of particles.

Secondly as the temperature $T^\circ$ tends to absolute zero the kinetic energy tends to zero and correspondingly,

$$\frac{3}{2} k_B T^\circ = \frac{1}{2} m \overline{v^2} \tag{89}$$

So the potential has two of the hallmarks needed for a BEC.

To determine the macroscopic behaviour of the potential I need to examine the probability flow density $J_p$ for the ground state of the Schrödinger equation,

$$\vec{J}_p = \frac{\hbar}{2 i m} \left(\Psi\left(\vec{\nabla} - q \vec{A}\right) \Psi^*\right) \tag{90}$$

introducing the dynamic $\theta$ and geometric $\gamma$ phases,

$$\Psi = \Psi_0 e^{i(\gamma - \theta)} \tag{91}$$

for the Higgs boson q = 0, letting $\theta = 0$, and taking the geometric phase as derived above as,

$$\gamma(t) = i \int \langle \psi_n | \nabla_R | \psi_n \rangle \cdot dR \tag{92}$$

this reduces the probability flow density to,

$$\vec{J}_p = \frac{\hbar \Psi_0^2}{2 i m} \vec{\nabla} \gamma = \frac{\hbar \Psi_0^2}{2 i m} \vec{\nabla} i \int \langle \psi_n | \nabla_R | \psi_n \rangle \cdot dR \tag{93}$$

simplifying,

$$\vec{J}_p = \frac{\hbar\,\Psi_0^2}{2\,m}\;\langle\psi_n\,|\nabla_x|\,\psi_n\rangle \tag{94}$$

by taking the fluid velocity $v_s$ and mass flow density $\rho_s$,

$$m\,\vec{J}_p = \rho_s\,v_s \tag{95}$$

since the density $\rho_s$ is also,

$$\rho_s = m\,\Psi_0^2 \tag{96}$$

therefore,

$$v_s = \frac{\hbar}{2\,m}\,\langle\psi_n\,|\nabla_x|\,\psi_n\rangle \tag{97}$$

converting to the momentum operator $\hat{P}$, it can be seen the fluid velocity is half the momentum,

$$v_s = \frac{1}{2\,m}\left\langle\psi_n\,|\hat{P}|\,\psi_n\right\rangle \tag{98}$$

Under Heisenberg uncertainty the potential will evolve cyclically as it moves back and forth over a mean point, so,

$$\gamma(C) = i\oint\langle\psi_n\,|\nabla_R|\,\psi_n\rangle\cdot dR \tag{99}$$

In this case I interpret the $\frac{1}{2}$ factor to indicate that half the time the potential is moving in one direction and the other half in the other direction.

If m is the sum of all the particles in the potential, then the velocity will be arbitrarily small which is in accord with,

$$\frac{3}{2}\,k_B\,T^\circ = \frac{1}{2}\,m\,\overline{v^2} \tag{100}$$

So in the absence of dynamical variables, the fluid velocity is directly proportional to the momentum and inversely proportional to the mass. The geometric phase operates on the potential as a whole, any fluctuations in the global state are reflected in the states of the particles that constitute the volume. Therefore if the ground state is comprised entirely of bosons at a temperature close to zero for an ideal gas, this constitutes a BEC and allows me to treat the entire potential as a BEC exhibiting macroscopic quantum phenomena where the boundaries are subject to Heisenberg indeterminacy.

§3-4 A Mechanism for Guth's Inflation

As discussed above the ground state of the Euclidean Hamiltonian equates to zero in the path integral formulation,

$$\mathcal{H}_0 = \mathbb{T} - \mathbb{U} = 0 \tag{101}$$

Allowing the universal wave equation to be written, where as discussed above $e^{i\,\gamma(t)}$ is a global phase change that applies both in $\mathbb{R}^4$ and $\mathbb{R}^{1,3}$.

$$\Psi_U = \Psi_0\, e^{i\,(\gamma(t) - \theta(t))} \tag{102}$$

Heisenberg's momentum-space uncertainty principle requires the width or maximal bound of this Hamiltonian tends to infinity, for as the kinetic energy tends to zero so the momentum tend to zero,

$$\lim_{\delta P_i \to 0} \frac{\hbar}{2\,\delta P_i} = \infty \Rightarrow \delta X_i \to \infty \Rightarrow X_i \to \infty \tag{103}$$

Equally the width or maximal bound of the temporal dimension time, tends to infinity under Heisenberg's energy-time uncertainty principle

$$\lim_{\delta E_i \to 0} \frac{\hbar}{2\,\delta E_i} = \infty \Rightarrow \delta t \to \infty \Rightarrow t \to \infty \tag{104}$$

Since $\gamma$(t) is imaginary,

$$\gamma(t) = i \int \langle \psi_n | \nabla_R | \psi_n \rangle \cdot dR \in C \to i\,\gamma \in \mathcal{R} \tag{105}$$

therefore $i\,\gamma \in \mathcal{R},\ i\,\theta \in C$ and the phases can never be equal.

It follows the total phase vanishes iff $\gamma = \theta = 0$, in which case the wavefunction remains a stationary state for all time and space,

$$\Psi(x,\ t)\ =\ \Psi_0\, e^{i\,(\gamma-\theta)} = \Psi_0\, e^{i\,0} \rightarrow\ \Psi\ =\ \Psi_0 \,\forall\ (x,\ t) \tag{106}$$

In other words Inflation could not take place, to overcome this problem it is necessary to examine fluctuations of $\gamma$,

$$\gamma\ =\ i\,(\gamma\ +\ \delta\gamma) \tag{107}$$

and again assuming the initial phases $\gamma = \theta = 0$, it follows the total phase is nonvanishing if,

$$e^{i\,(\gamma+\delta\gamma-\theta)}\ \neq\ 1 \tag{108}$$

then the universe can evolve dynamically,

$$\Psi(x,\ t)\ \neq\ \Psi_0 \,\forall\ (x,\ t) \tag{109}$$

A mechanism for this $\gamma$ fluctuation can be derived from the Berry phase,

$$\gamma(t)\ =\ i\int\langle\psi_n\,|\nabla_R|\,\psi_n\rangle\cdot\,dR \tag{110}$$

Since $\gamma$(t) is parametrized by R, approximate the fluctuation of $\gamma(t)$ by,

$$\gamma(t\ +\ \delta\mathrm{t})\ \simeq\ F(R)\ +\ F(\delta\mathrm{R}) \tag{111}$$

$$\gamma(t)\ \ +\ \gamma(\delta\mathrm{t})\ =\ \int\langle\psi_n\,|\nabla_R|\,\psi_n\rangle\cdot\,dR\ \ +\int\langle\psi_n\,|\nabla_R|\,\psi_n\rangle\,\delta R \tag{112}$$

let $\delta R = d$R,

$$\gamma(\delta\mathrm{t})\ =\ i\int\ \langle\psi_n\,|\nabla_R|\,\psi_n\rangle\cdot\,dR \tag{113}$$

it can be seen $\gamma(\delta t)$ is identical to $\gamma(t)$,

$$\gamma(\delta\mathrm{t})\ =\ \gamma(t) \tag{114}$$

The gHH requires the boundary of the universe is arbitrarily close to every point within $\mathbb{U}$, so the fluctuation is necessarily cyclic, therefore integrate $\gamma$(t) over a cycle C,

$$\gamma(C) = i \oint_C \langle \psi_n | \nabla_R | \psi_n \rangle \cdot dR \tag{115}$$

Griffiths[16-p337] pointed out "this is a line integral in the parameter space $\mathbb{R}^n$, and is not in general zero" - taking the non-zero integral implies $\gamma(C)$ cannot vanish if there is a fluctuation, it follows the uncertainty in the geometric phase must be greater than zero, and therefore,

$$e^{i\,\gamma(\delta t)} \neq 1 \tag{116}$$

$$\Psi_U = \Psi_0\, e^{i\,(\gamma(C) - \theta(t))} \neq \Psi_0 \;\forall\; (x, t) \tag{117}$$

Since $\gamma(t)$ and $\theta(t)$ are coupled together through $R$, any change in $\gamma$ is concomitant with a change in $\theta$ and vice-versa, implying any fluctuation in $\gamma(t)$ is accompanied by a fluctuation in $\theta(t)$ therefore the universe must evolve dynamically - a mechanism for this revolution will be given in the section on the Big Bang.

Summing up this section, the generalized Hartle-Hawking proposal holds that the boundary to the universe is arbitrarily close to every other point within the universe, the uncertainty in the global coördinates carries over into local coördinates through Berry's geometric phase, so any global fluctuation induces a local fluctuation, therefore if $\Psi_U$ expands it expands at all points within $\mathbb{U}$. It follows the bounds of $\mathbb{R}^{1,3}$ must expand when the total energy tends to zero, in other words in absence of energy - Space and Time must undergo an Inflationary phase near $\mathbb{U}_i$, and therefore I propose this as the mechanism for the Inflationary phase of the universe.

Lastly, since $\mathcal{H}_O$ is always zero, by the generalized Hartle-Hawking proposal there must always be microfluctuations everywhere, so Spacetime must Inflate locally, and therefore Inflation must be an ongoing process throughout the entire universe and this is consistent with observation[19] and

Andrei Linde’s proposal of eternal inflation [20].

## §3-5 Adiabatic Expansion

From the Bose-Einstein distribution

$$n(\epsilon) = \frac{1}{e^{\epsilon/k_B T} - 1} \tag{118}$$

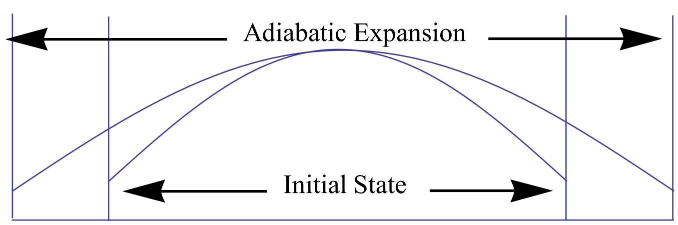
the number of particles for the ground state energy $\epsilon$ of $\mathbb{U}$ tends to infinity,

$$n(\epsilon) = \infty \tag{119}$$

it follows from the fluid velocity $v_s$ and geometric phase relation,

$$v_s = \frac{1}{2m} \left\langle \psi_n \middle| \hat{P} \middle| \psi_n \right\rangle \tag{120}$$

that the velocity tends to zero as n($\epsilon$) = ∞, and consequently the period of the cycle is infinite. Since the infinite potential prevents energy exchange beyond the boundary and since the process is infinitely slow it follows this system is characteristic of an Adiabatic process. The definition of the Adiabatic Theorem [12] "if a particle was initially in the nth eigenstate of the Hamiltonian $\mathcal{H}^i$ it will be carried (under the Schrödinger equation) in the nth eigenstate of $\mathcal{H}^f$."

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I require the quantum vacuum is isotropic and homogeneous before and after $\mathbb{U}_i$ - so the quantum vacuum appears the same before and after and this is only possible in the context of a quantal adiabatic expansion. Since the velocity of the expansion is arbitrarily small, since the particles remain in the ground state, and finally since the states of the new particles are non-holonomically different from the original particles: therefore the system satisfies Born and Fock's Adiabatic Theorem.

## §3-6 Quantum Vacuum and the Infinite Potential

The new Hamiltonian is always zero,

$$\mathcal{H}_O = \mathbb{T} - \mathbb{U} = 0 \tag{122}$$

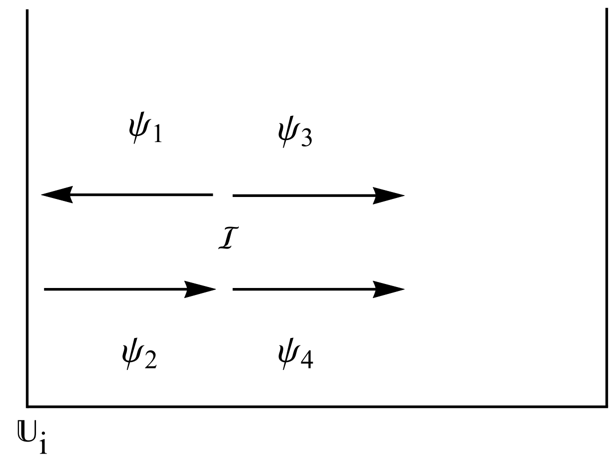
and this applies to all levels within the potential, and this means the total energy of a system of particles for all levels is always zero, and implies all particles must decay to the ground state. On the other hand Heisenberg's uncertainty principle also forbids a completely empty space and allows for the generation of virtual particle pairs $\{\overline{\phi}, \phi\}$, therefore a Spacetime vacuum energy must always be present. The trouble is how does the quantum vacuum behave within the potential and how does the quantum vacuum evolve into on-mass shell matter.

## §4 The Big Bang

From the premise that a mathematical space $\mathbb{R}^4$ transforms into the physical universe $\mathbb{R}^{1,3}$ and this necessarily requires a scalar field that transforms the Goldstone particle into a Higgs particle, I will discuss the revolution of the scalar field into matter by combining ideas of Inflation, the Quantum Vacuum, the Adiabatic Theorem and the generalized Hartle-Hawking no boundary proposal (gHH) to derive a model for the Big Bang.

### §4-1 Static Infinite Potential Well

Consider the virtual particle pair $\{\psi_1, \psi_3\}$ in a static infinite potential well, where $\psi_1$ is the antiparticle of $\psi_3$ or $\psi_1 = \overline{\psi_3}$; the choice of subscripts will soon be clear. According to the Feynman–Stückelberg Interpretation $\psi_1$, $\psi_3$ evolve along the temporal axis, until they reflect off $\mathbb{U}_i$, where $\mathbb{U}_i$ is the boundary of the potential and the beginning of the universe. Since the dimensions of the well do not change, the only result of a particle upon encountering the boundary is total reflection.

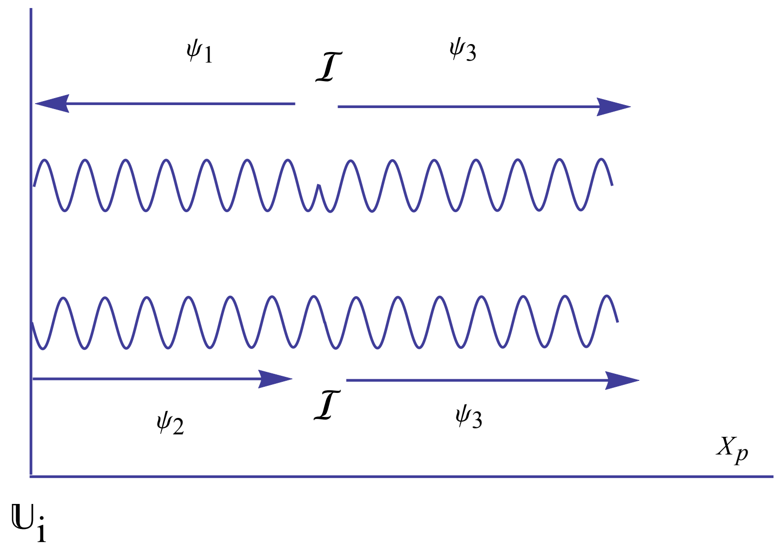



Step 1: At the point of instantiation $\mathbb{I}$ two virtual particles $\{\psi_1, \psi_3\}$ arise and they are in antiphase, and to conserve energy and momentum the energy and momentum of $\psi_1$ is equal and opposite to $\psi_3$.

Step 2: At $\mathbb{U}_i$ : An infinite step potential will always reflect a wavefunction away, therefore, $\psi_1$ transforms into $\psi_2$, and since $\psi_1$ is equal and opposite to $\psi_2$ in amplitude the waveforms sum to zero, necessarily there is no positive total energy in the Spacetime between $\mathbb{I}$ and $\mathbb{U}_i$ . Also, the retrograde momentum of $\psi_1$ cancels with the anterograde momentum of $\psi_2$, so there is also conservation of momentum between $\mathbb{I}$ and $\mathbb{U}_i$.

Step 3: After $\mathbb{I}$ : the reflected $\psi_2$ continues on past $\mathbb{I}$ to be relabelled as $\psi_4$.

Step 4: Since $\psi_1$ and $\psi_3$ are in antiphase, so $\psi_1$ and $\psi_2$ are in antiphase, $\psi_2$ and $\psi_3$ must be in phase - then it follows that $\psi_3$ and $\psi_4$ must be in phase.




Therefore the resulting positive energy particles are in phase, also, $\psi_3$ and $\psi_4$ have equal mass, charge, spin and momenta. If the particles are fermions this violates the Pauli Exclusion principle as they are identical fermions in the same state, so this solution is not permitted, in other words, the $\{\psi_3, \psi_4\}$ virtual fermions never occur and the $\{\psi_1, \psi_2\}$ cancel out to return to the quantum vacuum, these virtual particles always return to the quantum vacuum without a change in the total energy of the universe.

Dynamic Infinite Potential Well

A dynamic infinite potential well where the dimensions for $X_i \in \{t,x,y,z\}$ are determined by the uncertainties

$$X_i \simeq X_i \pm \delta X_i \tag{125}$$

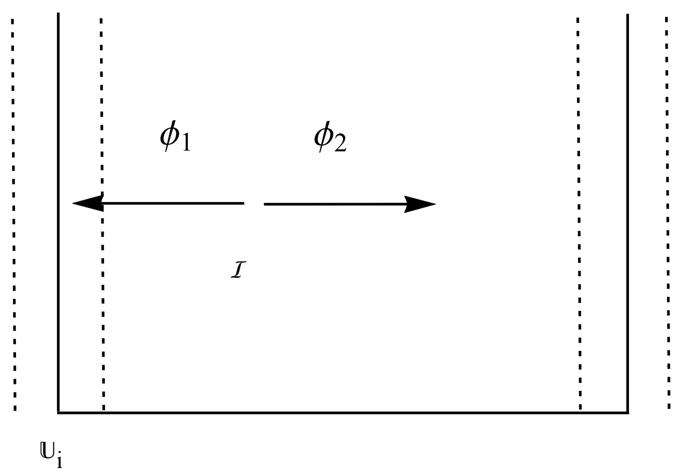
$$\delta X_i \geqslant \frac{\hbar}{2\,\delta P_i} \tag{126}$$

$$\delta X_0 \geqslant \frac{\hbar}{2\,\delta E_i} \tag{127}$$

and this has been shown to impose a global phase change,

$$\phi \rightarrow e^{i\gamma}\,\phi \tag{128}$$

In this case the uncertainty in Spacetime shifts all points within the potential in a cyclic manner.

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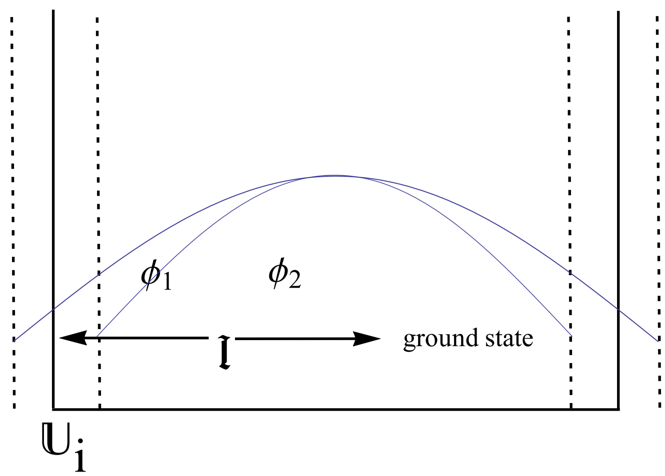
The new Hamiltonian requires the system never leaves the ground state

$$\mathcal{H}_O(\phi) = \mathbb{T}(\phi) - \mathbb{U}(\phi) = 0 \tag{130}$$

this means that as the system evolves the particles are carried around the ground state of the potential. For the ground state of an infinitely wide potential the velocity of the particles is infinitesimal and the cyclic change in volume in the potential is infinitesimally slow this - satisfying Fock and Born’s Adiabatic Theorem.




$\mathcal{H}_o$ also requires the generalized form of the Hartle-Hawking no boundary proposal - where as the energy of the system falls to zero then each point within the potential is arbitrarily close to the boundary.

This means:

1) the velocity of the particles is effectively zero;

2) the system is effectively adiabatic, and

3) the cyclic nature of the global phase change carries the particles to the boundary and back again,

The question of how a particle with zero velocity could move to a boundary is solved by moving the boundary to the particle, it is the boundary that has the kinetic energy $\mathbb{T}$, therefore the reflection and recombination is effectively immediate, adiabatic and universal.

This system is made considerably more complex by examining its four dimensional nature. Any fluctuation in $\mathbb{U}(\phi)$ results in a global phase change which is concomitant with a change in volume

$V_{\text{vol}}$ of the infinite potential, this cyclic global phase change is identical to the geometric phase change given by Berry,

$$\gamma_n(C) = i \oint \langle \psi_n \mid \nabla_R \mid \psi_n \rangle \cdot dR \tag{132}$$

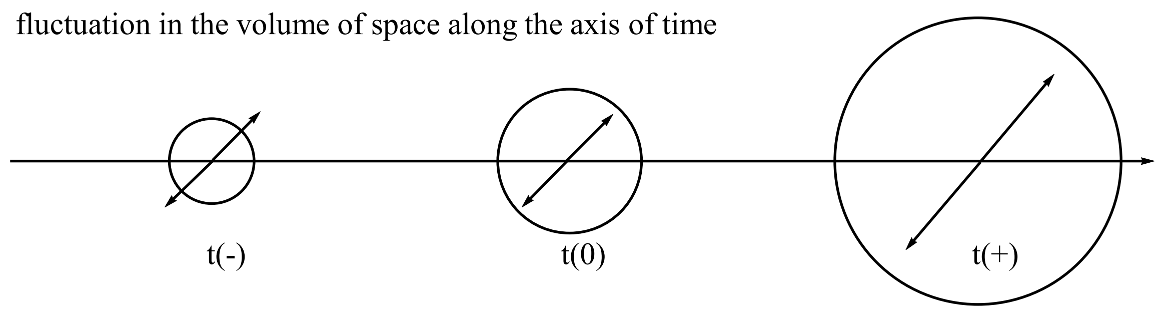
where the particle is carried around the potential by the global phase change.

Since the Heisenberg Uncertainty principle requires the uncertainty in the boundary decreases as the total energy increases, effectively in the future the distance from any point to a boundary is arbitrarily greater (in other words Inflation),

-this implies the distance antiparticles travel in the past to the boundary is less than the distance particles travel in the future-

To illustrate this consider the following diagram, the center circle is a random stage in a fluctuation of $\mathbb{U}(\phi)$, at this point a boson pair $\{\overline{\phi}, \phi\}$ of a particle $\phi$ and anti-particle $\overline{\phi}$ comes into existence. The Feynman–Stückelberg Interpretation requires $\overline{\phi}$ move backwards in time as $\phi$ moves forward in time, so in the past $\overline{\phi}$ move into a smaller volume as in the future $\phi$ moves into a larger volume.

fluctuation in the volume of space along the axis of time




(133)

So for an expanding volume the antiparticles are more likely to reflect off a boundary and return along the axis of time to their initial point $I$ than particles moving to a future boundary would return. It follows that as long as the universe is expanding then anterograde particles never reach the future boundary of $\mathbb{U}$, and only anti-particles (retrograde) particles would reflect, and this retrograde reflection of virtual antiparticles is the critical point in this paper.

## §4-2 The Revolution of Matter

The Hartle-Hawking no-boundary proposal holds that the identity of time and space become indistinguishable as the universal wave function approaches $\mathbb{U}_i$, this requires transforming from $\mathbb{R}^{1,3}$ to $\mathbb{R}^4$ as the Klein-Gordon equation reduces in the ground state of the potential well to the non-relativistic Schrödinger's equation, and I have shown this leads to a geometric phase shift,

$$| \psi(T) \rangle_{\mathbb{U}_i} = e^{i\,[\gamma_n(t) - \theta(t)]} \left| \psi(T(0)) \right\rangle \tag{134}$$

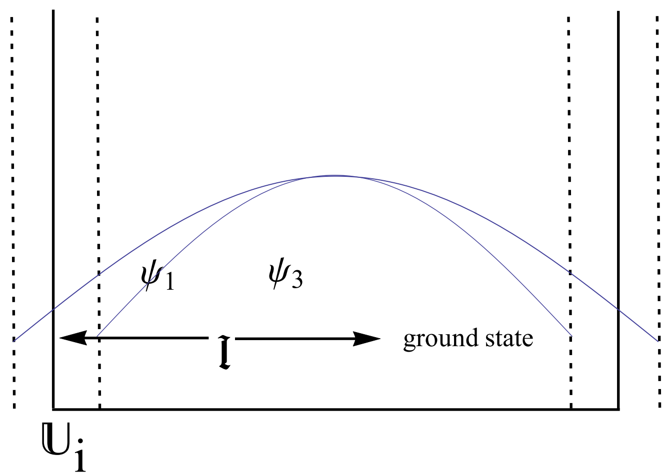
where the $\gamma$(t) depends on how the particle evolves through space

$$\gamma_n(t) = i \int \langle \psi_n \,|\, \nabla_R \,|\, \psi_n \rangle \cdot dR \tag{135}$$

The vacuum energy does not change from undergoing a geometric phase shift, as from the vacuum expectation value,

$$\langle O \rangle = \left\langle \psi \middle| e^{-i\,\gamma_n(t)}\, e^{i\,\theta(t)}\, e^{i\,\gamma_n(t)}\, e^{-i\,\theta(t)} \middle| \psi \right\rangle = \langle \psi^* \psi \rangle \tag{136}$$

In the case of the geometric phase shift the antiparticle $\psi_1$ upon reflection into $\psi_2$ does not return to its original point of origin $I$ for the space has expanded, so $\psi_2$ now is attempting to move into the state of another particle $\psi_3$, because the state of the particle is defined by not only its mass, charge, spin, energy but also its place in space and time.




This is clearly a nonholonomic process, driven by two different phases,

1: The dynamic phase $e^{-\theta(t)}$ of the particles evolving cyclically along $X_i$

2: The geometric phase $e^{\gamma(t)}$ of the potential evolving adiabatically along $X_i$

The two phases are equivalent to two different clocks, the internal clock $T_i$ or frequency of the virtual particle as it evolves through $\mathbb{R}^{1,3}$, and the external clock $T_e$ for the potential well derived from the adiabatic cycle caused by the intrinsic uncertainty of width R, and allows an exact solution of the universal wave function that includes admixtures of other states,

$$\Psi(x, t) = \psi_n(x, t)\, e^{i(\gamma(t) - \theta(t))} + \epsilon \sum_{m \neq n} c_m\, \psi_n(x, t) \tag{138}$$

$$\epsilon = \frac{T_{\text{internal}}}{T_{\text{external}}} \tag{139}$$

“Where $\epsilon$ characterizes the departure from adiabaticity (it goes to zero in the adiabatic limit)” [16-p339].

In contradistinction to symmetric and antisymmetric states these extra terms -which I label as asymmetric wave functions- are intrinsically Off Mass-Shell. This is fairly easy to show by taking standing waves in a potential well and adjusting the boundaries non-adiabatically, L → L + $\delta$L, the original standing waves are now the asymmetric non-solutions in the adjusted well, these asymmetric terms violate conservation of energy and are therefore non-physical. This is a important realization, for it divides the universal wave function into two parts, the first part constitutes the real On Mass-Shell universe and the second the virtual Off Mass-Shell universe of the quantum vacuum. It can been seen real particles lie on the axis of the wave function matrix and virtual particles off the axis, hence I will also refer to this division as on-axis and off-axis particles.

To show the exact formula of the universal wave equation includes the off axis or virtual terms for the quantum vacuum,

$$\Psi(x, t) = \psi_n(x, t)\, e^{i(\gamma(t) - \theta(t))} + \epsilon \sum_{m \neq n} c_m\, \psi_m(x, t) \tag{140}$$

start from a static universal wave function,

$$\Psi(x, t) = \Psi_0\, e^{i\,(\gamma - \theta)} = \Psi_0\, e^{i\,0} \to \Psi = \Psi_0 : \forall\ (x, t) = 0 \tag{141}$$

$$\Psi = \sum_{m\,n} c_{m\,n}\, \psi_{m\,n} = 0 \tag{142}$$

give this the adiabatic parameter $\epsilon$,

$$\Psi = \epsilon \sum_{m\,n} c_{m\,n}\, \psi_{m\,n} = 0 \tag{143}$$

This infinite sea of oscillators is identical to a quantum field, and matches the idea the universe is like a bubble of Hamiltonian action that fluctuates back and forth in time and space, where $\epsilon$ is the variable that shapes and changes the global structure. I can show this by assuming the internal energy of the universe equals the external energy then internal time and external time are in the same proportion as internal action $S_i$ and external action $S_e$,

$$\epsilon = \frac{T_i}{T_e} \simeq \frac{T_i}{T_e}\frac{E_i}{E_e} = \frac{S_i}{S_e} \tag{144}$$

Since the internal action is comprised of a set of oscillators $\psi$, I can take n as the number of $\psi$ and write $\sigma$ for the action of an internal particle,

$$\epsilon = \frac{n\,\sigma}{S_e} \tag{145}$$

drop n and consider the action for an arbitrary volume with arbitrary external action S,

$$\epsilon \geqslant \frac{\sigma}{S} \tag{146}$$

introduce the uncertainties,

$$\epsilon \geqslant \frac{\sigma}{\delta\text{E}\,\delta\text{t}} \geqslant \frac{\sigma}{E\,t} \geqslant \frac{\sigma}{S} \tag{147}$$

$\epsilon$ is a pure number so absorb $\epsilon$ into $\sigma$ and write it as $\hbar$, the $2\pi$ comes from the cyclic evolution of the volume,

$$1 \geqslant \frac{\hbar}{\delta\text{E}\,\delta\text{t}} \geqslant \frac{\hbar}{E\,t} \geqslant \frac{\hbar}{S} \tag{148}$$

since the volume is arbitrary I can contract this to the size of an elementary particle and derive the energy-time Heisenberg Uncertainty principle,

$$\delta\text{t} \geqslant \frac{\hbar}{\delta\text{E}} \tag{149}$$

similarly the exact same technique leads to the momentum-space Heisenberg Uncertainty principle,

$$\delta x \geqslant \frac{\hbar}{\delta p} \tag{150}$$

So in this model the Heisenberg Uncertainty principle and the adiabatic parameter are directly related, and the evolution of internal particles is directly related to the evolution of the universe as a whole, which on the surface appears similar to Dirac's Large Number Hypothesis[17] (LNH), however, the LNH requires a varying gravitational constant which violates the Perfect Cosmological principle, so for the moment I'm ignoring this possibility. The important part is that the individual dynamics of the internal particles which is governed by the dynamic and geometric phases are derived from the global adiabatic parameter.

Returning to the universal wave equation under the adiabatic parameter and expanding $\Psi$,

$$\Psi = \epsilon \begin{pmatrix} c_{11}\,\psi_{11} & c_{12}\,\psi_{12} & . & c_{1\,m}\,\psi_{1\,m} \\ c_{21}\,\psi_{21} & c_{22}\,\psi_{22} & . & . \\ . & . & . & . \\ c_{n\,1}\,\psi_{n\,1} & . & . & c_{n\,m}\,\psi_{n\,m} \end{pmatrix} \tag{151}$$

Separate the wave functions of the matrix into on-axis (real matter) and off-axis (virtual particles),

$$\Psi = \epsilon \begin{pmatrix} c_{11}\,\psi_{11} & 0 & . & 0 \\ 0 & c_{22}\,\psi_{22} & . & . \\ . & . & . & . \\ 0 & . & . & c_{n\,n}\,\psi_{n\,n} \end{pmatrix} + \epsilon \begin{pmatrix} 0 & c_{12}\,\psi_{12} & . & c_{1\,m}\,\psi_{1\,m} \\ c_{21}\,\psi_{21} & 0 & . & . \\ . & . & . & . \\ c_{m\,1}\,\psi_{m\,1} & . & . & 0 \end{pmatrix} \tag{152}$$

or more conveniently,

$$\Psi = \epsilon \sum_{n=n} c_n\,\psi_n + \epsilon \sum_{m \neq n} c_m\,\psi_m \tag{153}$$

Make the substitution $\epsilon = e^{i(\gamma-\theta)}$ where the phases arise from fluctuations in the universal potential as equivalent to fluctuations in $\epsilon$.

Group the real wave-functions together and sum over the on-axis terms,

$$\Psi = \psi_n e^{i(\gamma - \theta)} + \epsilon \sum_{m \neq n} c_m \psi_m \tag{154}$$

Calculate the expectation for Ψ,

$$\langle \Psi | \Psi \rangle = \left[\!\left[ \psi_n e^{i(\gamma - \theta)} + \epsilon \sum_{m \neq n} c_m \psi_m \right]\!\right]^* \left[\!\left[ \psi_n e^{i(\gamma - \theta)} + \epsilon \sum_{m \neq n} c_m \psi_m \right]\!\right] \tag{155}$$

$$= \left[\!\left[ \psi_n e^{-i(\gamma - \theta)} + \epsilon \sum_{m \neq n} c_m \psi^*{}_m \right]\!\right] \left[\!\left[ \psi_n e^{i(\gamma - \theta)} + \epsilon \sum_{m \neq n} c_m \psi_m \right]\!\right] \tag{156}$$

$$\begin{aligned} \langle \Psi | \Psi \rangle = {} & \psi_n e^{-i(\gamma - \theta)} \psi_n e^{i(\gamma - \theta)} + \psi_n e^{-i(\gamma - \theta)} \epsilon \sum_{m \neq n} c_m \psi_m + \\ & \psi_n e^{i(\gamma - \theta)} \epsilon \sum_{m \neq n} c_m \psi^*{}_m + \epsilon \sum_{m \neq n} c_m \psi^*{}_m \epsilon \sum_{m \neq n} c_m \psi_m \end{aligned} \tag{157}$$

By definition the m terms are orthogonal to the n terms, so the inner product of $\psi_n$ and $\psi_m$ is zero, reducing $\langle \Psi | \Psi \rangle$,

$$\langle \Psi | \Psi \rangle = \psi_n e^{-i(\gamma - \theta)} \psi_n e^{i(\gamma - \theta)} + \epsilon \sum_{m \neq n} c_m \psi^*{}_m \epsilon \sum_{m \neq n} c_m \psi_m \tag{158}$$

$$\langle \Psi | \Psi \rangle = |\psi_n|^2 + \epsilon^2 \left| \sum_{m \neq n} c_m \psi_m \right|^2 \tag{159}$$

In the adiabatic limit the second term vanishes leaving only On-Mass and On-Axis matter, it is not that the quantum vacuum does not exist but rather its asymmetric expectation is trivial, the on-axis terms are by definition on mass-shell. Remembering “Where ϵ characterizes the departure from adiabaticity (it goes to zero in the adiabatic limit)” and this is the critical idea, the adiabatic parameter regularizes the scalar field and places special constraints on how the scalar field can behave, and this now leads to the mechanism by which virtual particles are transformed into matter.

In a static infinite potential well the particles are determined solely by a dynamic phase and are either symmetric or antisymmetric under the exchange operator,

$$\Psi(2,\ 1) \ = \ e^{-i\,\theta}\,\Psi(1,\ 2) \tag{160}$$

for a cyclic evolution where the final state returns to its original point where $\theta$ equals $2\pi$, then for bosons,

$$\Psi(1,\ 2) \ = \ \Psi(1,\ 2) \tag{161}$$

for fermions this is impossible,

$$\Psi(1,\ 2) \ \neq \ -\Psi(1,\ 2) \tag{162}$$

In a dynamic infinite potential well the particles are also determined by the geometric phase,

$$\Psi(1,\ 2) \ = \ e^{i(\gamma - \theta)}\,\Psi(1,\ 2) \tag{163}$$

the geometric phase is in general always real and from Griffiths[16-p337] "this is a line integral in the parameter space $\mathbb{R}^n$, and is not in general zero"

Imagine the stationary wavefunction is zero, then the universal wavefunction depends solely on the adiabatic term,

$$\Psi(x,\ t) \ = \ \epsilon \sum_{m \neq n} c_m\,\psi_n(x,\ t) \tag{164}$$

and any fluctuation is determined by the asymmetric off-axis wave functions, however, as pointed out, any fluctuation gives rise to $\gamma$(t) and since $\gamma$(t) is coupled to $\theta$(t) then it is impossible not to have a wavefunction for a Dynamic Infinite Potential Well.

For a cyclic fluctuation,

$$\gamma_n(C) = i \oint \langle \psi_n | \nabla_R | \psi_n \rangle \cdot \mathrm{dR} > 0 \quad \text{and} \quad i\, \gamma_n(R) \in \mathcal{R} \tag{165}$$

where a particle is carried from its original point to the boundary and returns to its transported point,

$$\Psi(1, 2) \neq e^{i(\gamma - 2\pi)}\, \Psi(1, 2) \tag{166}$$

has no solution, this is the asymmetric state and results from a departure in the adiabaticity and the parallel transport of the particle.

Since there are no symmetric states, only asymmetric or antisymmetric, it follows that even pairs of bosons cannot return to their original state and must scatter off each other, this is in great contradistinction to the Bose-Einstein statistics, which allow for an infinite number of particles in the ground state. For example if the bosons are initially a photon and an antiphoton, it follows pairs of photons must conflate from the boundary, and there is recent evidence to support this [32].

Now for the important part of this paper, first noting fermions are subject to Relativistic Phase (or the Relativity of Simultaneity) in which case the following theorem must occur:

$$\begin{gathered}\text{If fermions } \{\psi_3\,,\ \psi_4\} \text{ are in phase with the same velocity and energy at the} \\ \text{same point in Spacetime } \Rightarrow \text{ they must be in simultaneous relativistic phase}\end{gathered} \tag{167}$$

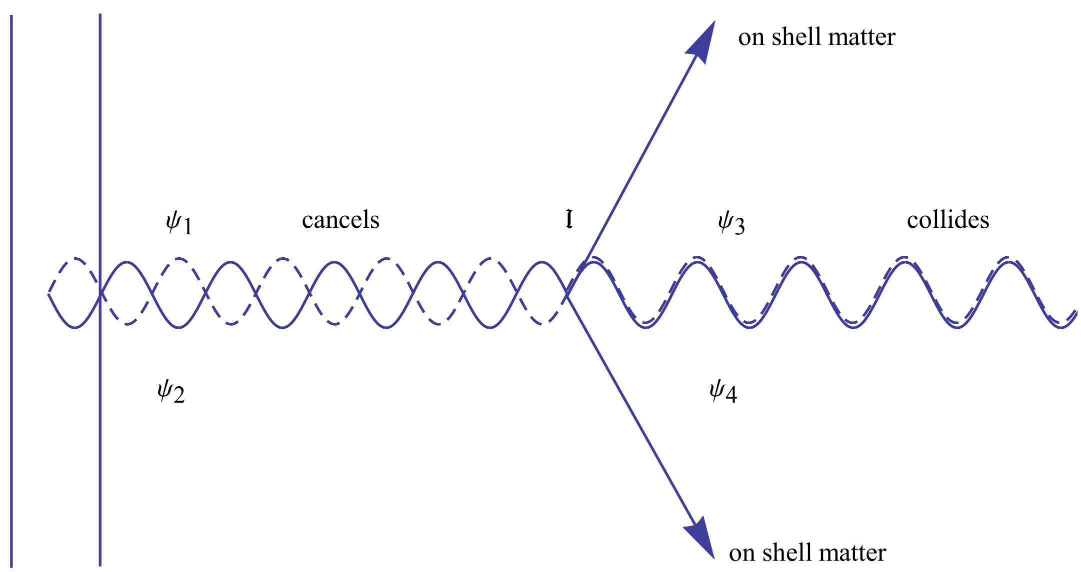
$$\begin{gathered}\text{if } \{\psi_3\,,\ \psi_4\} \text{ at the same point in } X_{1,3} \text{ are in simultaneous relativistic phase } \Rightarrow \\ \text{special principle of relativity must hold}\end{gathered} \tag{168}$$

$$\text{if special principle of relativity holds } \Rightarrow\ \{\psi_3\,,\ \psi_4\} \text{ must be on} - \text{mass shell} \tag{169}$$

$$\begin{gathered}\text{if } \{\psi_3\,,\ \psi_4\} \text{ are on mass} - \text{shell and in identical states } \Rightarrow \\ \text{this must violate the Pauli Exclusion principle}\end{gathered} \tag{170}$$

$$\begin{gathered}\text{if } \{\psi_3\,,\ \psi_4\} \text{ violate the Pauli Exclusion principle } \Rightarrow \\ \text{they must scatter off each other with an exchange of photons } \gamma\end{gathered} \tag{171}$$

$$\begin{gathered}\text{Therefore by Lorentz covariance the exchange of photons} \\ \text{requires the resulting particles } \{\psi_3,\ \psi_4\} \text{ must be on mass} - \text{shell.}\end{gathered} \tag{172}$$




(173)

A close examination of the diagram (173) will reveal the change in phase at $\mathbb{I}$, note how the $\psi_1$ and $\psi_2$ phases cancel exactly conserving energy for virtual particles, and the $\psi_3$ and $\psi_4$ phases are identical and in indentical space thus violating the Pauli Exclusion principle and this *causes* matter to be ejected. In other words, this is the point at which CAUSE and EFFECT begins, out of the virtual and into the real.

The energy for the on mass-shell particles is derived from the kinetic term in the new Hamiltonian in $\mathbb{R}^4$, and is divided into the kinetic and potential terms in $\mathbb{R}^{1,3}$, with the potential terms represented by the Electro-Weak and Strong forces,

$$\mathcal{H}_0 = \mathbb{T} - \mathbb{U} = 0 \tag{174}$$

$$\mathbb{T} = T + V \tag{175}$$

$\mathbb{U}$ is transformed into the gravity potential, and I will give a mechanism for this transformation in the section on gravity,

$$\mathbb{U} = G \tag{176}$$

All this leads to the Hamiltonian for $\mathbb{R}^{1,3}$,

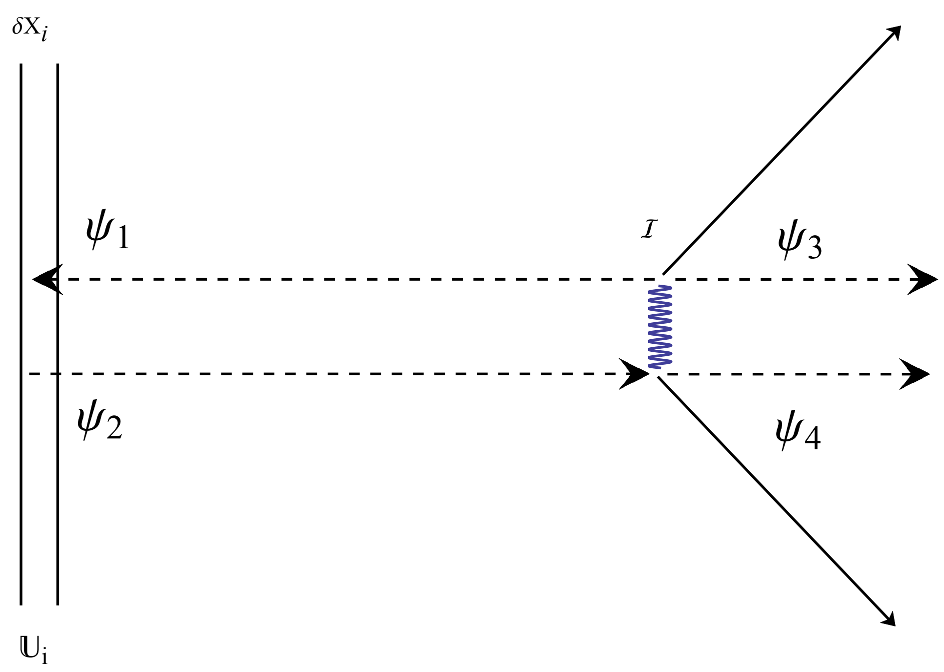
$$\mathcal{H}_M = T + V - G = 0 \tag{177}$$

This cyclic, adiabatic evolution occurs instantly throughout the initial state of the universe, with matter in the form of positive energy on-mass shell particles the only possible result from a fluctuation of the universe, and in so doing provides a solution to the antimatter problem of Wheeler's grand idea of a One Electron universe. Since the process is rapid, cyclic and forms matter I accordingly call this the Revolution of Matter. The underlying principles of quantum mechanics used here are so clear and well proven, and the process of reflection and collision is so patently obvious that I am convinced this is the mechanism for the Big Bang.

Evidence for these massive particle pairs may have been recently observed at the LHC in 2010 [CMS Collaboration (2010) [Observation of Long-Range, Near-Side Angular Correlations in Proton-Proton Collisions at the LHC. http://arxiv.org/abs/1009.4122]].

## Kocktail diagram

The diagram for this Revolution of Matter is labelled the Kocktail diagram (178) from its similarity to a cocktail glass. Where $\mathbb{I}$ is the point at which the Big Bang takes place; $\mathbb{U}_\mathrm{i}$ is the boundary of the universe and the potential well, $\delta \mathrm{X}_i$ the uncertainty in the boundary of the universe is generalized Hartle-Hawking Uncertainty.




(178)

The reverse process is forbidden both under Pauli Exclusion Principle as the antiparticles to $\{\psi_3, \psi_4\}$ in $\mathbb{R}^{1,3}$ cannot move into the same state at $\mathbb{I}$, as that would also violate conservation of energy and momentum within $\mathbb{R}^{1,3}$. Equally the reverse diagram under crossing symmetry is forbidden under violation of conservation of four momenta and violates Pauli's exclusion principle - effectively as long as the universe expands then positrons cannot spontaneously appear within the universe.

§5 Universally Identical Fermions

Since bosons are not bound by the Pauli Exclusion Principle, an infinite number of bosons would exist in the ground state of $\mathbb{U}$, and the energy for all these bosons is dependent on the new Hamiltonian,

$$\mathcal{H}_0 = \mathbb{T} - \mathbb{U} = 0 \tag{179}$$

It can be inferred from the gHH that each point in space is arbitrarily close to every other point before the Big Bang, and each point is arbitrarily close to the boundaries. Therefore each boson is arbitrarily close to every other boson. As the space expands the bosons can decay to fermions, also undergoing a cyclic evolution determined by the geometric phase,

$$\gamma_n(C) = i \oint \langle \psi_n \mid \nabla_R \mid \psi_n \rangle \cdot dR \tag{180}$$

thereupon the reflected fermion $|\psi_2\rangle$ is carried geometrically to a new point in Spacetime to meet $|\psi_3\rangle$. The cyclic condition closely matches Wheeler's model of the one electron universe, in this case the fermions do not evolve to any future boundary as the expansion takes place faster. Fermions are bound by the Pauli Exclusion Principle, and since it is forbidden under the Pauli Exclusion principle that $|\psi_3\rangle = |\psi_4\rangle$ the conflated fermions must exchange photons

$$|\psi_3\rangle + |\psi_4\rangle + |\gamma\rangle \neq |0\rangle \tag{181}$$

Since under the gHH rule each fermion is arbitrarily close to every other fermion, therefore each fermion scatters off every other fermion.

$$|\psi_1\rangle + |\psi_2\rangle + |\psi_3\rangle + |\psi_4\rangle + |\gamma\rangle \neq |0\rangle \tag{182}$$

Since only two fermions are allowed in the ground state the rest are driven into higher energy levels.

Importantly all the daughter fermions derive their energies from the intrinsic uncertainty of the ground state of the potential well, it follows initially that each fermion has identical energy, and

therefore all fermionic particles of the same species have identical masses. (183)

Hence I propose that all fermionic particles, such as electrons, quarks and neutrinos, are identical because they conflate from identical ground state bosons, since bosons in the same state are identical - it can been seen there is only one boson from which all electrons are derived, and this resolves the problem of why all the electrons in our universe are identical, and provides a solution to Wheeler's[1] grand idea of a 'one electron universe'.

§6 Newton’s First Law

For a closed universe the sum of forces on a free particle is,

$$\sum \mathbb{F}_i = 0 \tag{184}$$

and energy is conserved,

$$\sum T - V = 0 \tag{185}$$

This statement of Newton’s First Law begs the question how does an object free of external forces, remain at rest or move in uniform velocity in a straight line in comparison to the comoving frame of the universe? A solution exists within the framework of the geometric potential with its associated geometric phase, the geometric phase as was shown above is a global phase,

$$\phi \to e^{i\gamma}\, \phi \tag{186}$$

Any change in the geometric potential has a concomitant change in local phases, where local phases govern dynamic variables, this all leads to a exact universal wave function where $\gamma$(t) is the geometric phase, $\theta$(t) is the dynamic phase and $\epsilon$ the adiabatic parameter,

$$\Psi(x,\, t) = \psi_n(x,\, t)\, e^{i(\gamma(t) - \theta(t))} + \epsilon \sum_{m \neq n} c_m\, \psi_n(x,\, t) \tag{187}$$

For adiabatic limit as $\epsilon$ tends to zero and given zero dynamical variables, as in the state where the sum of forces on a free particle are zero, this reduces to,

$$\Psi = \int \mathrm{dx}\, \Psi_0\, e^{i[\gamma(t)]} \tag{188}$$

For the case where the geometry is unchanging this reduces to a constant, then the initial state of a particle remains the same until the dynamics or the geometry changes, which is identical to

Newton’s First Law,

$$\Psi = \int dx\, \Psi_0 * \text{constant} \tag{189}$$

This relates directly to Mach’s Principle, where the global phase applies to every frame of reference in the universe, it follows that any local frame of reference has the same global phase as derived from the geometric potential.

For non-zero adiabatic parameter, of the exact universal wave function as for a state far from matter in distant space,

$$\Psi(x,\ t) = \psi_n(x,\ t)\, e^{i\,\gamma(t)} + \epsilon \sum_{m \neq n} c_m\, \psi_n(x,\ t) \tag{190}$$

where $\epsilon > 0$, then fluctuations in Newton’s First Law can be expected.

An analogy can be made with Newton's bucket, where changing the depth of the water in the bucket is equivalent to changing the geometric potential $\mathbb{U}$. If the bucket is spun up the water moves up the side of the bucket and forms a hollow in the center, yet the total volume of water is unchanged, this idea of spinning up the water is analogous to a fluctuation in the potential. If the bucket is translated adiabatically the depth of water is unchanged and the water continues to rotate identically to the untranslated state.

The geometric potential is a global change of state, and the geometric variables determine the local states within the bucket, so a more intuitive way of understanding this, would be to say the geometric potential is Newton's bucket, changing the potential is identical to changing the bucket. It can now be seen the geometric phase ultimately builds to Newton's First Law of Motion, and from this it follows that geometric space is comparable with Newton's concept of absolute space and time in Principia:

“I. Absolute, true and mathematical time, of itself, and from its own nature flows equably without regard to anything external, and by another name is called duration: relative, apparent and common time, is some sensible and external (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time; such as an hour, a day, month, a year.

II. Absolute space, in its own nature, without regard to anything external, remains always similar and immovable. Relative space is some movable dimension or measure of the absolute spaces; which our senses determine by its position to bodies; and which is vulgarly taken for immovable space; such is the dimension of a subterranean, an æreal, or celestial space, determined by its position in respect of the earth. Absolute and relative space, are the same in figure and magnitude; but they do not remain always numerically the same. For if the earth, for instance, moves, a space of our air, which relatively and in respect of the earth remains always the same, will at one time be one part of the absolute space into which the air passes; at another time it will be another part of the same, and so, absolutely understood, it will be perpetually mutable.” - Definition VIII Scholium Principia

The underlying premise of my paper is that Minkowski Spacetime is derived from Euclidean space under the Wick Rotation,

$$\mathbb{R}^4 = (X_0, X_1, X_2, X_3) \quad \underset{\longleftrightarrow}{\text{Wick}} \quad \mathbb{R}^{1,3} = (T, X, Y, Z) \tag{191}$$

Leading to a new Hamiltonian,

$$\mathcal{H}_O(\phi) = \mathbb{T}(\phi) - \mathbb{U}(\phi) = 0 \tag{192}$$

Ultimately this leads to Newton’s Laws of Motion, and within this context the geometric space of Einstein’s Relativity are derived, and this leads to the premise that Newton’s Euclidean absolute space and time provides the groundwork for Einstein’s non-Euclidean Spacetime, which is such a uncomfortable idea I’m inclined to dismiss it, however, the argument is so strong, so cogent, and so efficient in hammering out so many problems, that I’m forced to conclude the geometric phase not only lays the foundation of Spacetime for the entire history of the universe - it also provides a framework upon which to build the stars.

## §7 The Vacuum Catastrophe

Calculating the energy expectation for the Hamiltonian $\mathcal{H}_0$ it can be seen the second term is arbitrarily small,

$$\langle \Psi | \mathcal{H}_0 | \Psi \rangle = E_n |\psi_n|^2 + \epsilon^2 E_n \left| \sum_{m \neq n} c_m \psi_m \right|^2 \tag{193}$$

Before the Revolution of Matter there are only virtual particles, reducing the energy expectation to the second term,

$$\langle \Psi | \mathcal{H}_0 | \Psi \rangle = \epsilon^2 E_n |\psi_m|^2 \tag{194}$$

In the adiabatic limit,

$$\epsilon = \lim_{T_e \to \infty} \frac{T_i}{T_e} \to 0 \quad \text{and} \quad \epsilon^2 \ll \epsilon \tag{195}$$

Therefore the energy of the vacuum can be made arbitrarily small as the vacuum expectation value (VEV) is driven to zero, since by quantum field theory the zero-point energy indicates a value of $10^{121}$ GeV/m$^3$, which is in great contrast to that given by experimental results from the Voyager spacecraft of about $10^{14}$ GeV/m$^3$[18], it can be seen the large zero-point energy value is extinguished by the Adiabatic limit $\epsilon^2$, and the Vacuum Catastrophe fades away like a rumour on the nightwind.

# §8 Gravity

## §8-1 Bubbles of Nothing

Returning to the idea I put forward at the beginning of this paper that the universe is like a bubble of Hamiltonian action that oscillates in Euclidean space, which derived from an idea by Edward Tyron[14] in 1969, where as he put it “I visualized the universe erupting out of nothing as a quantum fluctuation and I realized that it was possible that it explained the critical density of the universe.”

Inside the surface of the bubble the system is determined by the internal action $S_i$ and outside by the external action $S_e$ on the surface,

$$S_i \approx S_e \tag{196}$$

By conservation of energy - the energy of the internal surface is equal to the energy of the external surface,

$$E_i = E_e \tag{197}$$

so the action varies proportional to the internal and external periods,

$$\frac{S_i}{S_e} = \frac{E_i\, T_i}{E_e\, T_e} = \frac{T_i}{T_e} \tag{198}$$

This reduces to the original form of the adiabatic parameter $\epsilon$,

$$\epsilon = \frac{S_i}{S_e} = \frac{T_i}{T_e} \tag{199}$$

$\epsilon$ can be written in terms of wavelength for photons, with photons are the limiting case for any arbitrary volume,

$$T_i = \frac{1}{\omega_i} \quad ; \quad T_e = \frac{1}{\omega_e} \tag{200}$$

$$\epsilon = \frac{T_i}{T_e} = \frac{\omega_e}{\omega_i} \tag{201}$$

$$\omega = \frac{c}{\lambda} \tag{202}$$

$$\frac{\omega_e}{\omega_i} = \frac{c}{\lambda_i} \frac{\lambda_e}{c} = \frac{\lambda_e}{\lambda_i} \tag{203}$$

$$\epsilon = \lim_{\lambda_e \to \infty} \frac{\lambda_e}{\lambda_i} = 0 \tag{204}$$

let $\lambda_i$ be the interior radius $R_i$, $\lambda_e$ be the exterior radius $R_e$,

$$\epsilon = \frac{R_e}{R_i} \tag{205}$$

$$\epsilon = \lim_{R_e \to R_i} \frac{R_e}{R_i} = 1 \tag{206}$$

From the previous sections where it was shown that any fluctuation in $S_e$ leads to the Revolution of Matter and the quantum vacuum, and drawing an arbitrary volume around any point $\psi$(x,t) leads to the scale factor General Relativity.

$$a(t) \approx \lambda_e(T_e) \tag{207}$$

Writing the exact equation for the universal wave equation, where the universe is separated into terms for observable matter and the virtual particles of the quantum vacuum,

$$\Psi(x, t) = \psi_n(x, t)\, e^{i(\gamma(t) - \theta(t))} + \epsilon \sum_{m \neq n} c_m \psi_m(x, t) \tag{208}$$

this can be generalized to give a new universal wave equation in terms of action, since the internal energy equals the external energy this reduces to the previous equation,

$$\Psi(x,\ t)\ =\ \psi_n(x,\ t)\, e^{i(\gamma(t) - \theta(t))}\ +\ \lim_{S_e \to \infty} \frac{S_i}{S_e} \sum_{m \neq n} c_m\, \psi_m(x,\ t) \tag{209}$$

which in its most generalized form is,

$$\Psi(x,\ t)\ =\ \frac{S_i}{S_e} \sum_{m\,n} c_{m\,n}\, \psi_{m\,n}(x,\ t) \tag{210}$$

By the Heisenberg indeterminacy there are always fluctuations in $\epsilon$,

$$\epsilon\ =\ \lim_{T_e \to \infty} \frac{T_i}{T_e}\ >\ 0 \tag{211}$$

with concomitant fluctuations in $\gamma$,

$$\psi_n\ = 0 \Rightarrow \gamma = i(\gamma + \delta\gamma) = i\,\delta\gamma \tag{212}$$

Therefore there must be an irreducible energy term that expands Spacetime and I expect this to be proportional to the Cosmological constant,

$$\epsilon \propto \Lambda \tag{213}$$

To show this, first I’m going to set the expansion of Spacetime $\dot{R}$(t) in terms of the Heisenberg uncertainty relations for space and time, with strict equalities for the ground state of an infinite potential, take the relationship between the internal action $S_i$ and the external action $S_e$ of any arbitrary volume of space,

$$S_i\ =\ S_e \tag{214}$$

writing the actions in terms of the Heisenberg relations,

$$1 = \frac{S_i}{S_e} = \frac{E_i\, t}{\mathbb{P}_e\, x} \tag{215}$$

$$\delta x = \frac{\hbar}{\delta \mathbb{P}} \;\; ; \;\; \delta t = \frac{\hbar}{\delta E} \tag{216}$$

combine them to give the expansion of Spacetime $\dot{R}$(t),

$$\dot{R}(t) = \frac{\delta x}{\delta t} = \frac{\hbar}{\delta \mathbb{P}} \frac{\delta E}{\hbar} = \frac{\delta E}{\delta \mathbb{P}} \cong \frac{E}{\mathbb{P}} \tag{217}$$

Therefore I require an expansion of Spacetime in terms of energy and momentum. There are three types of fields which can be used to construct this expansion rate, first a Massive Field like Dark Matter, second a massless like a Photon Field, and thirdly the virtual field or the Vacuum Field in the presence of matter.

Case 1 (Massive Field): If the Spacetime field has particles with mass m > 0, and velocity v,

$$\mathbb{P} = \mathrm{m\,v} \;\; ; \;\; E^2 = (\mathbb{P}\, c)^2 + \left(\mathrm{m}\, c^2\right)^2 \tag{218}$$

$$\dot{R}(t)^2 = \frac{\delta E^2}{\delta \mathbb{P}^2} = \frac{\delta\left[(\mathrm{m\,v}\, c)^2 + \left(\mathrm{m}\, c^2\right)^2\right]}{\delta\, (\mathrm{m\,v})^2} \tag{219}$$

this has the congruency,

$$\frac{\delta\left[(\mathrm{m\,v}\, c)^2 + \left(\mathrm{m}\, c^2\right)^2\right]}{\delta\, (\mathrm{m\,v})^2} \cong \frac{(\mathrm{m\,v}\, c)^2 + \left(\mathrm{m}\, c^2\right)^2}{(\mathrm{m\,v})^2} \tag{220}$$

$$\dot{R}(t)^2 = \frac{(\mathrm{m\,v}\, c)^2 + \left(\mathrm{m}\, c^2\right)^2}{(\mathrm{m\,v})^2} = c^2 + \left(\frac{\mathrm{m}\, c^2}{\mathrm{m\,v}}\right)^2 \tag{221}$$

$$\dot{R}(t) = \sqrt{\left(c^2 + \left(\frac{\mathrm{m}\, c^2}{\mathrm{m\,v}}\right)^2\right)} = \sqrt{\left(c^2 + \left(\frac{c^2}{\mathrm{v}}\right)^2\right)} \tag{222}$$

For all values of v then $\dot{R}(t)$ > c violating special relativity, so a solution of the expansion of Spacetime in terms of the Heisenberg uncertainty relations for a field of massive particles is impossible.

Case 2 (Photon Field): If the field has particles with m = 0,

$$\dot{R}(t)^2 = \frac{\delta E^2}{\delta \mathbb{P}^2} \cong \frac{(\mathbb{P}\, c)^2}{\mathbb{P}^2} = c^2 \tag{223}$$

$$\dot{R}(t) = c \tag{224}$$

Let Spacetime be a quantum field of massless quantum oscillators, where E = h $\omega$ and P = $E_\omega / c$,

$$\dot{R}(t) = \frac{\delta x}{\delta t} = \frac{\hbar}{\delta \mathbb{P}} \frac{\delta E}{\hbar} = \frac{\delta\, h\, \omega}{\delta\, (h\, \omega / c)} \cong \frac{h\, \omega}{h\, \omega / c} = c \tag{225}$$

Therefore if m = 0 the massless scalar field expands at the speed of light.

Case 3 (Vacuum Field): Quantum vacuum in the neighbourhood of matter, in this case the radial expansion is given in terms of the internal energy density for a volume pushing outwards divided by the external pressure inwards,

$$\dot{R}(t) = \frac{E_i}{\mathbb{P}_e} = \frac{E_m + E_v}{\mathbb{P}_m + \mathbb{P}_v} \tag{226}$$

Take an infinitesimal area $dx^2$ at distance R from a mass $M_0$(R = 0), and $\dot{R}(t)$ can be rewritten in terms of the mass energy density and vacuum force per unit area for an infinitesimal period of time, in the neighbourhood of matter $E_m \gg E_v$ and $E_v$ be ignored; the frame of reference will be taken as the same as the matter so $\mathbb{P}_m = 0$,

$$\dot{R}(t) = \frac{E_i}{\mathbb{P}_e} = \frac{E_m + E_v}{\mathbb{P}_m + \mathbb{P}_v} = \frac{E_m}{\mathbb{P}_v} = \frac{\rho_m c^2 R^3}{p_v \delta t R^2} = \frac{\rho_m c^2 R}{p_v \delta t} \tag{227}$$

The vacuum pressure $p_v$ is inverse square proportion to the distance from the mass, since at a quantum level an electron interacts with the quantum vacuum shifting it to a higher energy level, for instance - the vacuum pressure is greatest at the surface of an electron and least at infinity. Therefore the rate of expansion is directly proportional to the distance from the mass. Far from matter the energy density of matter falls to zero $E_m \to 0$, and the energy density of the vacuum can no longer be ignored $E_v > 0$, so the system behaves as in Case 2 for a Photon Field.

$$\dot{R}(t) = \frac{E_m + E_v}{\mathbb{P}_m + \mathbb{P}_v} = \frac{E_v}{\mathbb{P}_v} = c \tag{228}$$

In other words, as the energy in an infinitesimal volume grows to infinity the expansion of Spacetime falls to zero, and therefore the expansion of Spacetime is inversely proportional to the energy in the region adjacent to it. The expansion is directly proportional to the presence of matter and directly proportional to the distance R from matter to a point in the vacuum. This leads to a dramatic understanding of the nature of gravity, it is not that matter has a gravitational field, *it is that* Spacetime *expands everywhere, expanding greatest when furtherest from matter*, and therefore any test particles moving along a geodesic will move along the path of least expansion to the point of greatest energy density.

The above relation can be simplified,

$$\dot{R}(t) = \frac{\rho_m c^2}{p_v} \dot{R}(t) \tag{229}$$

$$p_v = \rho_m c^2 \text{ or } \frac{p_v}{\rho_m} = c^2 \tag{230}$$

For the static case the pressure of the vacuum is equal and opposite to the energy density of matter, if however, time $\delta$t fluctuates in,

$$\dot{R}(t) = \frac{\rho_m c^2 R}{p_v \delta \mathrm{t}} \tag{231}$$

the motion of a particle will follow that of minimal expansion.

It is now possible to construct a dynamic where the expansion of Spacetime behaves as the absorption of virtual particles, as an example of Huygen's principle, where each point in space is an expanding wave, summing over all the waves the fields exert a force, carrying the particles to the point of minimal expansion, i.e. the greatest mass. Another name for a quantum field of massless quantum oscillators is the photon field, it follows that since photons have light pressure which can push on matter then this expansion of Spacetime is identical to Le Sage's theory of gravitation, there are, however, problems with Le Sage's theory of Drag, Aberration, Range and Heat. Heat is the most important, as inelastic collisions leads to unphysical solutions, primarily the thermal energy of the universe going to infinity, and as was shown in case one, a field of massive particles is impossible. Therefore if the expansion of Spacetime was due solely to a *virtual* photon field with off-axis and off mass-shell photons, where the virtual particles are also the foundation of Spacetime itself, then the virtual photons do not heat up matter rather they cause the expansion of Spacetime and the problems of Drag, Aberration, Range and Heat of matter are neatly obviated. In this model the movement of matter is determined by the geometry of Spacetime and not by what Le Sage called ultra-mundane corpuscles impacting from every direction, but there is a clear similarity between the two models.

The scalar curvature in $R$ in Einstein's field equation,

$$R_{\mu\upsilon} - \frac{1}{2} R\, g_{\mu\upsilon} + \Lambda\, g_{\mu\upsilon} \ = 8\,\pi\,\mathcal{G}\left(T_{\mu\upsilon}^{(M)} + \epsilon\,\rho_v\, g_{\mu\upsilon}\right) \tag{232}$$

is inversely proportional to $\lambda_e$,

$$R \propto \frac{1}{\lambda_e} \tag{233}$$

Therefore take any arbitrary volume and increase it to the volume of the universe - the scalar curvature tends to zero, on the other hand by the gHH in the zero-energy state of the scalar field $\phi$, it is possible to draw arbitrarily small volumes around any point in $\mathbb{R}^{1,3}$ as

$$\lambda_e \to \lambda_i \tag{234}$$

the scalar curvature is non-zero, at this point the Revolution of Matter takes places and drives the universe away from the ground state.

It is now possible to determine the Cosmological constant in terms of the adiabatic parameter, first writing Einstein's field equation with the cosmological constant, where $\mathcal{G}$ is the gravitational constant,

$$R_{\mu\upsilon} - \frac{1}{2} R\, g_{\mu\upsilon} + \Lambda\, g_{\mu\upsilon} = 8\,\pi\, \mathcal{G}\, T_{\mu\upsilon} \tag{235}$$

separate the stress-energy tensor into matter ($M$) and virtual ($V$) terms,

$$= 8\,\pi\,\mathcal{G}\left(T^{(M)}_{\mu\upsilon} + T^{(V)}_{\mu\upsilon}\right) \tag{236}$$

$$= 8\,\pi\,\mathcal{G}\left(T^{(M)}_{\mu\upsilon} + \rho_v\, g_{\mu\upsilon}\right) \tag{237}$$

$$\Lambda = 8\,\pi\,\mathcal{G}\,\rho_v \tag{238}$$

Treating the exact universal wave equation as a perfect fluid and positing the stress-energy tensor exists at each point in $\Psi(R^{1,3})$, separating both $T_{\mu\upsilon}$ and into real and virtual parts,

$$T_{\mu\upsilon} = T^{(M)}_{\mu\upsilon} + T^{(V)}_{\mu\upsilon} \tag{239}$$

the expectation,

$$\left\langle \Psi \middle| T_{\mu\upsilon} \middle| \Psi \right\rangle = \left\langle \psi_{ij} \middle| T_{\mu\upsilon} \middle| \psi_{ij} \right\rangle = \left\langle \psi_{ij} \middle| T^{(M)}_{\mu\upsilon} \middle| \psi_{ij} \right\rangle + \left\langle \psi_{ij} \middle| T^{(V)}_{\mu\upsilon} \middle| \psi_{ij} \right\rangle \tag{240}$$

include the adiabatic parameter,

$$\begin{gathered} \left\langle \psi_{m\,n} \middle| T_{\mu\upsilon} \middle| \psi_{m\,n} \right\rangle = \\ \left\langle \psi_n(x,\,t)\, e^{i(\gamma(t) - \theta(t))} \middle| T^{(M)}_{\mu\upsilon} \middle| \psi_n(x,\,t)\, e^{i(\gamma(t) - \theta(t))} \right\rangle_{m=n} + \left\langle \epsilon\, \psi_{m\,n} \middle| T^{(V)}_{\mu\upsilon} \middle| \epsilon\, \psi_{m\,n} \right\rangle_{m \neq n} \end{gathered} \tag{241}$$

$$\begin{gathered} \left\langle \psi_{m\,n} \middle| T_{\mu\upsilon} \middle| \psi_{m\,n} \right\rangle = \\ \left\langle \psi_n(x,\,t)\, e^{i(\gamma(t) - \theta(t))} \middle| T^{(M)}_{\mu\upsilon} \middle| \psi_n(x,\,t)\, e^{i(\gamma(t) - \theta(t))} \right\rangle_{m=n} + \left\langle \psi_{m\,n} \middle| \epsilon\; T^{(V)}_{\mu\upsilon} \middle| \psi_{m\,n} \right\rangle_{m \neq n} \end{gathered} \tag{242}$$

In the adiabatic limit as $\epsilon \to 0$ this reduces to the expectation for matter,

$$\left\langle \psi_{m\,n} \middle| T_{\mu\upsilon} \middle| \psi_{m\,n} \right\rangle = \left\langle \psi_n(x,\,t)\, e^{i(\gamma(t) - \theta(t))} \middle| T^{(M)}_{\mu\upsilon} \middle| \psi_n(x,\,t)\, e^{i(\gamma(t) - \theta(t))} \right\rangle_{m=n} \tag{243}$$

for the non-adiabatic evolution of the wave equation $\gamma \to 0$, reducing the above to the standard energy expectation for a wave equation,

$$\left\langle \Psi \left| T_{\mu\upsilon} \right| \Psi \right\rangle = \left\langle \psi_n(x,\, t)\, e^{-i\,\theta(t)} \left| T^{(M)}_{\mu\upsilon} \right| \psi_n(x,\, t)\, e^{-i\,\theta(t)} \right\rangle_{m=n} \tag{244}$$

in the absence of matter and such that $\epsilon > 0$,

$$\left\langle \Psi \left| T_{\mu\upsilon} \right| \Psi \right\rangle = \left\langle \psi_{mn} \left| \epsilon \mathrm{T}^{(V)}_{\mu\upsilon} \right| \psi_{mn} \right\rangle_{m \neq n} \tag{245}$$

It can be seen the adiabatic parameter regularizes the quantum vacuum and provides a solution to the problem of Renormalization.

The stress-energy tensor can now be written,

$$T_{\mu\upsilon} = T^{(M)}_{\mu\upsilon} + \epsilon\, T^{(V)}_{\mu\upsilon} \tag{246}$$

Applied to the stress-energy tensor in Einstein’s field equation,

$$R_{\mu\upsilon} - \frac{1}{2} R\, g_{\mu\upsilon} + \Lambda\, g_{\mu\upsilon} = 8\,\pi\,\mathcal{G}\left(T^{(M)}_{\mu\upsilon} + \epsilon\, T^{(V)}_{\mu\upsilon}\right) \tag{247}$$

the adiabatic parameter carries over to the vacuum density $\rho_v$,

$$R_{\mu\upsilon} - \frac{1}{2} R\, g_{\mu\upsilon} + \Lambda\, g_{\mu\upsilon} = 8\,\pi\,\mathcal{G}\left(T^{(M)}_{\mu\upsilon} + \epsilon\, \rho_v\, g_{\mu\upsilon}\right) \tag{248}$$

let,

$$T^{(M)}_{\mu\upsilon} = 0 \tag{249}$$

Therefore in the absence of matter the curvature of Spacetime is determined solely by the adiabatic parameter multiplied by the energy density of the quantum vacuum,

$$\Lambda = 8\,\pi\,\mathcal{G}\,\epsilon\,\rho_v \tag{250}$$

separate the stress-energy tensor into real and virtual parts,

$$R_{\mu\upsilon} - \frac{1}{2} R\, g_{\mu\upsilon} \;=\; 8\,\pi\, \mathcal{G}\, T^{(M)}_{\mu\upsilon} \tag{251}$$

$$\Lambda\, g_{\mu\upsilon} \;=\; 8\,\pi\, \mathcal{G}\, \epsilon\, \rho_v\, g_{\mu\upsilon} \tag{252}$$

Since $\mathcal{G}$ is a constant, I'm going to apply $\epsilon$ to instances of $\rho_v$ in Friedmann's acceleration equations,

$$\frac{\ddot{R}(t)}{R} \;=\; -\frac{4\,\pi\,\mathcal{G}}{3}\left(\rho_m + \frac{3\,p_v}{c^2}\right) + \frac{\Lambda}{3} \tag{253}$$

introduce vacuum density $\rho_v$ for the interior volume and vacuum pressure $p_v$, solving for vacuum pressure $p_v$ in terms for density,

$$p_v \;=\; -\rho_v\, c^2 \tag{254}$$

include the adiabatic parameter,

$$p_v \;=\; -\epsilon\, \rho_v\, c^2 \tag{255}$$

introduce $p_v$ and the new cosmological constant into Friedmann's equation,

$$\frac{\ddot{R}(t)}{R} \;=\; -\frac{4\,\pi\,\mathcal{G}}{3}\,(\rho_m - \;3\,\rho_v\,\epsilon) + \frac{8\,\pi\,\mathcal{G}\,\epsilon\,\rho_v}{3} \tag{256}$$

$$\frac{\ddot{R}(t)}{R} \;= -\frac{4\,\pi\,\mathcal{G}\,\rho_m}{3} + \frac{12\,\pi\,\mathcal{G}\,\epsilon\,\rho_v}{3} + \frac{8\,\pi\,\mathcal{G}\;\epsilon\,\rho_v}{3} \tag{257}$$

$$\frac{\ddot{R}(t)}{R} \;=\; -\frac{4\,\pi\,\mathcal{G}\,\rho_m}{3} + \frac{20\,\pi\,\mathcal{G}\,\epsilon\,\rho_v}{3} \tag{258}$$

so the acceleration field is given by,

$$\ddot{R}(t) \;=\; -\frac{4\,\pi\,\mathcal{G}\,\rho_m\,R}{3} + \frac{20\,\pi\,\mathcal{G}\,\epsilon\,\rho_v\,R}{3} \tag{259}$$

By the Heisenberg relations the adiabatic parameter is inversely proportional to the presence of matter,

$$R \to 0 \Rightarrow \epsilon \to 0 \tag{260}$$

For low R where $\rho_m \gg \epsilon\, \rho_v$ this reduces to Newton's Law,

$$\ddot{R}(t) = -\frac{\mathcal{G}\, m}{R^2} < 0 \tag{261}$$

For large R where $\rho_m \ll \epsilon\, \rho_v$ , as $\rho_m \to 0$, this gives a solution,

$$\ddot{R}(t) = -\frac{4\,\pi\, \mathcal{G}\, \epsilon\, \rho_v}{3}\, R \tag{262}$$

This model predicts that far from the presence of matter in the extra-galactic spaces,

$$R \to \infty \Rightarrow \ddot{R}(t) > 0 \tag{263}$$

So the pressure of the quantum vacuum on the geometry of Spacetime gives Newtonian gravity an extra push, and this is identical to the effect of Dark Matter and the expansion of the universe. Gravity in this model is a pseudoforce that depends on the geometry of the quantum vacuum, where Dark Matter ceases to be a form of matter and is reduced to merely an attribute of the quantum vacuum. The other forces of Electro-Weak and Strong are exchange fields operating under the Heisenberg Uncertainty principle, the weak nuclear force comes from the exchange of virtual W and Z bosons, the Coulomb force from the exchange of virtual photons, the strong nuclear force from the exchange of virtual mesons. I can now posit that the Heisenberg Uncertainty principle is responsible for the gravitational field by its effect on the expansion of Spacetime, therefore all the fields of physics are derived from a single underlying mathematical structure - the unifying principle of the universe is the Heisenberg Uncertainty principle.

## §8-2 Flat Rotation Curves for Galaxies

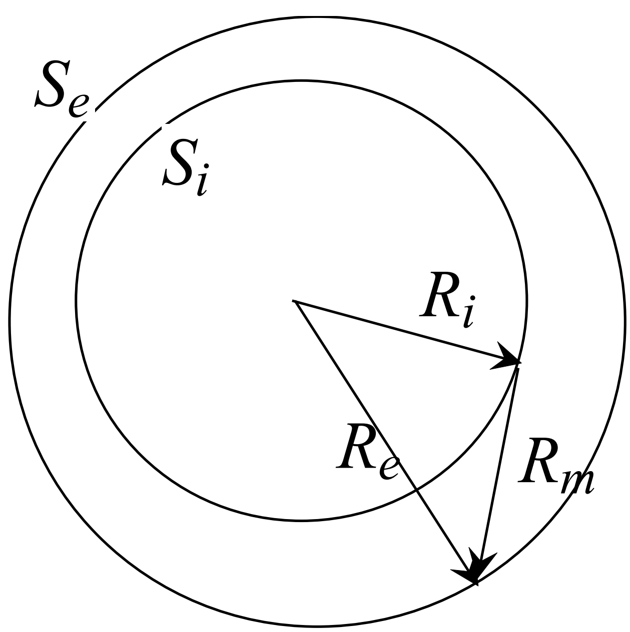
Returning to the original premise that the universe is a quantum fluctuation of bubble of action,

$$\epsilon = \frac{S_i}{S_e} = \frac{E_i\, T_i}{E_e\, T_e} = \frac{T_i}{T_e} \tag{264}$$

this can be written in terms of the interior and exterior of the surfaces of the bubble of action,

$$\epsilon = \frac{S_i}{S_e} = \frac{\mathbb{P}_i\, R_i}{\mathbb{P}_e\, R_e} = \frac{R_i}{R_e} \tag{265}$$

Define the distance $R_m$ as the distance from mass m to an arbitrary point within the fluctuation, i.e., a distance between the surfaces of the bubble,




By Newton's Shell theorem a spherically symmetric shell has zero net gravitational field within the volume,

$$R_m^2 = R_e^2 - R_i^2 \tag{266}$$

$$R_i^2 = R_e^2 - R_m^2 \tag{267}$$

$$\epsilon = \frac{R_i}{R_e} = \frac{\sqrt{R_e^2 - R_m^2}}{R_e} = \sqrt{1 - \frac{R_m^2}{R_e^2}} \tag{268}$$

$$\epsilon = \sqrt{1 - \frac{R_m^2}{R_e^2}} \tag{269}$$

$$\ddot{R}(t) = -\frac{4\pi \mathcal{G} \rho_m R}{3} + \frac{20\pi \mathcal{G} \rho_v R}{3} \sqrt{1 - \frac{R_m^2}{R_e^2}} \tag{270}$$

Adjust the sign,

$$\ddot{R}(t) = -\frac{4\pi \mathcal{G} \rho_m R}{3} + \frac{20\pi \mathcal{G} \rho_v R}{3} \sqrt{1 - \frac{R_m^2}{R_e^2}} \tag{271}$$

solve for the orbital velocity,

$$\frac{m v^2}{R} = \frac{\mathcal{G} M m}{R^2} = G(R) \tag{272}$$

$$v^2 = \frac{\mathcal{G} M}{R} \tag{273}$$

$$G(R) = \frac{4\pi \mathcal{G} \rho_m R}{3} - \frac{20\pi \mathcal{G} \rho_v R}{3} \sqrt{1 - \frac{R_m^2}{R_e^2}} \tag{274}$$

$$\frac{m v^2}{R} = \frac{4\pi \mathcal{G} \rho_m R}{3} - \frac{20\pi \mathcal{G} \rho_v R}{3} \sqrt{1 - \frac{R_m^2}{R_e^2}} \tag{275}$$

$$v = \sqrt{\left(\frac{4\pi \mathcal{G}\, \rho_m R}{3} - \frac{20\pi \mathcal{G}\, \rho_v R}{3} \sqrt{1 - \frac{R_m^2}{R_e^2}}\right)} \tag{276}$$

Far from the presence of matter in the extra-galactic spaces where

$$R \to \infty \Rightarrow \epsilon \gg 0 \tag{277}$$

there is a probability of Revolution of Matter taking place, it follows that matter should still be forming far from galactic centers, and in some peculiar geometries where the expansion of Spacetime is so rapid, as for the case of a black hole where the Revolution of Matter is expressed as Hawking radiation. Starting from my vacuum version of Friedmann's acceleration equation, and apply this in the vicinity of a Black Hole, where the B.H. field is so extreme it removes all matter from the surface of the event horizon.

$$\ddot{R}(t) = -\frac{4\pi \mathcal{G}\, \rho_m R}{3} - \frac{4\pi \mathcal{G}\, \epsilon^2 \rho_v R}{3} \tag{278}$$

Now take an arbitrary volume dV near the event horizon which has no matter. It follows that in the absence of matter $\rho_m = 0$ and $\epsilon >> 0$,

$$\ddot{R}(t) = -\frac{4\pi \mathcal{G}\, \epsilon^2 \rho_v R}{3} \tag{279}$$

Immediately the Revolution of Matter takes place and the equation reverts to the exact universal wave equation where $\rho_m > 0$ and $\epsilon \to 0$, and as the acceleration equation reverts $\ddot{R}(t)$ so the cycle is repeated. This process is directly proportional to the size of $\epsilon$, which would be expected to fluctuate wildly like a storm in the ergosphere, yielding much greater matter the Hawking

Radiation[21]. Since the energy for the Revolution is derived from the gravitational field and since most of the newly formed matter falls into the event horizon then energy is conserved, however, at the poles the Blandford–Znajek process can be expected to extract matter via the magnetic field and this secondary process could give rise the relativistic jets. There is, however, evidence by Hjellming and Rupen[22] the relativistic jets are episodic due to accretion of matter which is to be expected as the distribution of matter in space is random, so the size of the jets might be a combination of accretion of matter and the process of Revolution, so to test this would need an examination of Black Holes in the absence of accreting matter.

Returning to the vacuum version of Friedmann’s acceleration equation,

$$\ddot{R}(t) = -\frac{4\pi \mathcal{G} \rho_m R}{3} - \frac{4\pi \mathcal{G} \epsilon^2 \rho_v R}{3} \tag{280}$$

it can be seen this model is similar in principle to Jeans, Hoyle, Gold and Bondi's Steady State theory, so surprisingly this leads to the idea that the Big Bang theory (which Hoyle derided) and Hoyle's own Steady State theory can be reconciled - albeit reconciled distantly. Indeed the similarity of this model to Hoyle's latter Quasi-steady state cosmology model [23] later presented by Hoyle is remarkable.

## §9 Flatness, Horizon and Monopole Problems

Three problems with the hot big bang cosmology are the 'flatness problem', 'horizon problem' and 'monopole suppression' as discussed.

### §9-1 Flatness problem

Implicit in this model is a flat universe as based on the Euclidean Hamiltonian where the total energy density of the universe is zero,

$$\mathcal{H}_E\left(\mathbb{R}^4\right) = \mathbb{T} - \mathbb{U} = 0 \tag{281}$$

By definition the curvature k for zero energy density is zero, since Inflation is universal which lowers the energy density $\rho$, there must be some mechanism to increase $\rho$ and this takes places via the formation of new matter far from the galactic centers.

Before the Big Bang the spatial extent of the Euclidean space is infinite, and in turn the spatial extent of Minkowski Spacetime must be infinite after the Big Bang. After the Big Bang as Minkowski Spacetime accumulates energy in the form of fermions and photons, at this stage Minkowski Spacetime breaks free from Euclidean space and can be considered a space in its own right. Since I require $\mathbb{R}^4$ to transform continuously and uniformly at all points to $\mathbb{R}^{1,3}$ then the curvature of $\mathbb{R}^{1,3}$ must equal the curvature of $\mathbb{R}^4$, it naturally follows the curvature of $\mathbb{R}^{1,3}$ is zero by the addition of gravity,

$$\mathcal{H}_M\left(\mathbb{R}^{1,3}\right) = T + V - G = 0 \tag{282}$$

where as Spacetime expands or contracts, or matter is conflated, the total energy remains zero, so concomitant with gravity the revolution of matter is driven by the expansion of space. It follows quite simply that the universe is driven to a flat curvature.

The expansion $\dot{R}(t)$ is given in terms of energy density and vacuum pressure,

$$\dot{R}(t) = \frac{E_i}{\mathbb{P}_e} = \frac{E_m + E_v}{\mathbb{P}_m + \mathbb{P}_v} = \frac{E_m}{\mathbb{P}_v} = \frac{\rho_m c^2 R^3}{p_v \, \delta\mathrm{t} \, R^2} = \frac{\rho_m c^2 R}{p_v \, \delta\mathrm{t}} \tag{283}$$

The total energy and momentum of the universe is constant independent of the scale factor, and R can be taken for the scale factor a(t),

$$E_i = E_m + E_v \tag{284}$$

$$\mathbb{P}_e = \mathbb{P}_m + \mathbb{P}_v \tag{285}$$

Take any arbitrary volume, if the vacuum energy falls to zero then via the Revolution of Matter the energy density of matter increases, if the energy density of matter falls to zero then the scale factor increases and the volume expands, it follows that total curvature of the universe remains flat which averaged over sufficiently large volumes.

## §9-2 Horizon Problem

As was shown previously the generalized Hartle-Hawking no boundary proposal suggests all points within the potential are arbitrarily close, therefore each of the femion states can be treated as a region that is causally connected to all the other regions, since each fermion can communicate with all the other bosons at the speed of light before the singularity expands. On the basis of this alone, the Horizon Problem is avoided, and the universe will evolve from this state in a homogeneous manner.

## §10 Sakharov Conditions

These are conditions suggested by Andrei Sakharov[7] as necessary to produce more matter than antimatter at the Big Bang

1: Baryon number violation.

2: C-symmetry and CP-symmetry violation.

3: Interactions out of thermal equilibrium.

## §10-1 Baryon number B violation:

Baryon number is defined as

$$\mathrm{B} = 1/3\left(n_q - n_{\overline{q}}\right) \tag{286}$$

$n_q$ , $n_{\overline{q}}$ are the number of quarks and anti-quarks, and for the quantum vacuum $\sum \mathrm{B} = 0$ irrespective of whether the quarks are virtual or not. Write $\mathbb{K}(\mathrm{B})$ for transformation of the baryon number through revolution, and noting there is no revolution for positive energy states, then

$$\mathbb{K}\,(\mathrm{B}) = 1/3\left(n_q - \mathbb{K}(n_{\overline{q}})\right) = 2/3\; n_q \tag{287}$$

$$\mathbb{K}(\mathrm{B}) \neq \mathrm{B} \tag{288}$$

The Revolution of baryons from the vacuum satisfies the first of the Sakharov conditions of baryon B number violation, as the total number of baryons must increase.

## §10-2 Violations for C-symmetry and CP-symmetry:

This next section follows closely J.M.Cline's excellent paper on Baryogenesis [25]

From the Feynman-Stückelberg Interpretation time is reversed for a particle moving backwards in time, similarly charge is conjugated and parity is inverted. So revolution is actually three separate transformations, temporal T reversal, charge C conjugation and parity P inversion. Write $\mathbb{K}$(s) and $\mathbb{K}$(q) for transformation of the parity number and charge number through Revolution. Under Revolution charge number is conjugated,

$$\mathbb{K}(\overline{\mathrm{q}}) = \mathrm{q} \tag{289}$$

Parity inverts the sense of space P($r$) = ($-r$) or

$$P : \begin{pmatrix} x \\ y \\ x \end{pmatrix} \to \begin{pmatrix} -x \\ -y \\ -x \end{pmatrix} \tag{290}$$

Like parity so Revolution requires matter have extension in space and there is evidence to support this [#][#] in other words, a parity transformation requires matter to be three dimensional and not a singular point.

Comparing revolution with these symmetry transformations for complex scalar fields, fermions, and vector fields:

Complex scalar fields

$$\mathrm{C} : \phi \to \phi^* \tag{291}$$

$$\mathrm{P} : \phi(\mathrm{t}, \vec{\mathrm{x}}) \to \mp\phi(\mathrm{t},\text{-}\vec{\mathrm{x}}) \tag{292}$$

$$\mathrm{T} : \phi(\mathrm{t}, \vec{\mathrm{x}}) \to \phi(\text{-}\mathrm{t},\vec{\mathrm{x}}) \tag{293}$$

$$\mathrm{CP} : \phi(\mathrm{t}, \vec{x}) \to \phi^*(\mathrm{t},\text{-}\vec{\mathrm{x}}) \tag{294}$$

$$\text{CPT} : \phi(\text{t}, \vec{x}) \to \phi^*(\text{-t,-}\vec{\text{x}}) \tag{295}$$

In comparison with $\mathbb{K}$

$$\mathbb{K} : \phi(\text{t}, \vec{x}) \to \phi^*(\text{-t,-}\vec{\text{x}}) = \text{CPT} \tag{296}$$

Fermions

$$\text{C} : \psi_L \to i\, \sigma_2\, \psi_L{}^* \,, \psi_R \to -\, i\, \sigma_2\, \psi_R{}^* \,, \psi \to i\, \gamma^2\, \psi^* \tag{297}$$

$$\text{P} : \psi_L \to \psi_R\, (\text{t, -}\vec{\text{x}}) \,, \psi_R \to \psi_L\, (\text{t, -}\vec{\text{x}}) \,, \psi \to \gamma^0\, \psi\, (\text{t, -}\vec{\text{x}}) \tag{298}$$

$$\text{T} : \psi_L \to \psi_L\, (-\text{t, }\vec{\text{x}}) \,, \psi_R \to \psi_R\, (-\text{t, }\vec{\text{x}}) \,, \psi \to \gamma^0\, \psi\, (-\text{t, }\vec{\text{x}}) \tag{299}$$

$$\text{CP} : \psi_L \to i\, \sigma_2\, \psi_R{}^*(\text{t, -}\vec{\text{x}}) \,, \psi_R \to -\, i\, \sigma_2\, \psi_L{}^*(\text{t, -}\vec{\text{x}}) \,, \psi \to i\, \gamma^2\, \psi^*(\text{t,-}\vec{\text{x}}) \tag{300}$$

CPT :

$$\psi_L \to i\, \sigma_2\, \psi_R{}^*(-\text{t, -}\vec{\text{x}}) \,, \psi_R \to -\, i\, \sigma_2\, \psi_L{}^*(-\text{t, -}\vec{\text{x}}) \,, \psi \to i\, \gamma^2\, \psi^*(\text{-t,-}\vec{\text{x}}) \tag{301}$$

In comparison with $\mathbb{K}$ :

$$\psi_L \to i\, \sigma_2\, \psi_R{}^*(-\text{t, -}\vec{\text{x}}) \,, \psi_R \to -\, i\, \sigma_2\, \psi_L{}^*(-\text{t, -}\vec{\text{x}}) \,, \psi \to i\, \gamma^2\, \psi^*(\text{-t,-}\vec{\text{x}}) \tag{302}$$

Vector fields $\text{A}_\mu$

$$\text{C} : \text{A}_\mu \to \text{-A}_\mu \tag{303}$$

$$\text{P} : \text{A}_\mu(\text{t}, \vec{x}) \to (\text{A}_0\text{,-}\, \overrightarrow{\text{A}})(\text{t,-}\vec{\text{x}}) \tag{304}$$

$$\text{T} : \text{A}_\mu(\text{t}, \vec{x}) \to (-\text{A}_0,\, \overrightarrow{\text{A}})(\text{-t,}\vec{\text{x}}) \tag{305}$$

$$\text{CP} : \text{A}_\mu(\text{t}, \vec{x}) \to (\text{-A}_0,\, \overrightarrow{\text{A}})(\text{t,-}\vec{\text{x}}) \tag{306}$$

$$\text{CPT} : \text{A}_\mu(\text{t}, \vec{x}) \to (\text{-A}_0,\, \text{-}\overrightarrow{\text{A}})(\text{-t,-}\vec{\text{x}}) \tag{307}$$

$$\mathbb{K} : \text{A}_\mu(\text{t}, \vec{x}) \to (\text{-A}_0,\, \text{-}\overrightarrow{\text{A}})(\text{-t,-}\vec{\text{x}}) \tag{308}$$

Revolution conjugates charge, inverts space and reverses time,

$$\mathbb{K} = CPT \tag{309}$$

Upon quantum reflection charge and parity are reversed, spin however remains the same, so Revolution requires C and CP symmetry violation. Sakahrov's second condition requires violations for C-symmetry and CP-symmetry, and it can be seen Revolution readily satisfies these. It also satisfies CPT symmetry, and a more pleasingly symmetric result is hard to find.

## §10-3-1 Evolution out of Thermal Equilibrium

Firstly: thermal equilibrium in Sakharov's sense refers to reversible processes at the Big Bang,

$$X \to Y + B \tag{310}$$

Where X is some initial baryon state, Y the final state, B excess baryons produced.

Equilibrium is balanced by a reverse process

$$Y + B \to X \tag{311}$$

Writing Γ for rate of reaction, and modeling X and Y as Boltzmann distributions of baryons, the two baryon gases are in equilibrium when

$$\Gamma(X \to Y + B) = \Gamma(Y + B \to X) \tag{312}$$

In the Revolution model, however, Baryon number where quark number is again defined,

$$B = 1/3\left(n_q - n_{\overline{q}}\right) \tag{313}$$

the quark number transforms according to,

$$\mathbb{K}\,(B) = 1/3\left(n_q - \mathbb{K}(n_{\overline{q}})\right) = 2/3\; n_q \tag{314}$$

$$\mathbb{K}(\mathrm{B}) \neq \mathrm{B} \tag{315}$$

$$\mathbb{K}(\Gamma(\mathrm{X} \to \mathrm{Y} + \mathrm{B})) \neq \Gamma(\mathrm{Y} + \mathrm{B} \to \mathrm{X}) \tag{316}$$

the reverse process does not take place as resultant baryons are anterograde in time and cannot reflect off $\mathbb{U}_i$. Therefore Revolution is a transformation out of thermal equilibrium and satisfies Sakharov third condition.

# §11 Predictions

## §11-1 Infinite space ∞

By applying the Heisenberg uncertainty principle to the Euclidean potential, I have shown Euclidean space has maximum uncertainty in the vicinity of the Big Bang where the total energy is zero, and it follows from this that the Revolution of matter takes place over an infinite volume. Entailed in this, is the proposition that our universe is also of infinite volume, it seems contradictory that our visible universe which we see as starting from a unique singularity is also infinite in extent, but this is a consequence of the limitations of the speed of light, where we can only observe to the limit of the Hubble Distance. It is, however, entirely feasible in the sense of a Cantor's Set of points to construct a series of universe nucleation points, where like our universe, an infinite series of universes just like ours start from seperate points and each Inflates into a visible universe with identical laws and properties of matter to ours, complete with people, rabbits and scientists. These other universes are contiguous with ours, so the model I have presented predicts a universe with infinite volume, therefore should a limit to our universe be observed that would be a negative test of the model and disprove the principle of Revolution.

## §11-2 Space is flat everywhere ⌢

The curvature of space is defined by the total energy within that space, for Euclidean space the total energy is given by the Euclidean Hamiltonian,

$$\mathcal{H}_E\left(\mathbb{R}^4\right) = \mathbb{T} - \mathbb{U} = 0 \tag{317}$$

It follows the curvature for $\mathbb{R}^4$ before the Big Bang is zero. Since I require the total energy before the Big Bang must equal the total energy after, this necessitates the inclusion of the gravitational field, with an equation of state for a flat universe

$$\mathcal{H}_M\left(\mathbb{R}^{1,3}\right) = T + V - G = 0 \tag{318}$$

It should be relatively easy to test for a flat universe in $\mathbb{R}^{1,3}$ by measuring the total matter and gravitational fields and averaging over regions of space across the cosmos, this would be a test for this model. If the total energy of matter and gravity averaged across the entire universe is not zero, then the model I have presented here is incorrect, so to disprove the model requires a universe which is curved. If, however, as was pointed out above our universe is part of a larger universe it is possible of a local curvature across our visible universe, so this would be a weak test of the model.

## §11-3 Pairs of particles at Big Bang $\Longleftrightarrow$

Fundamental to Revolution is the principle that pairs of particles would form in the Big Bang epoch, and evidence for such double particles should be present in the Cosmic Microwave Background, however, due to the violence of the Big Bang it would be extremely difficult to observe such double particles. A solution may lay in the coherence of gas clouds of doublets over vast regions, where huge numbers of double particles with identical energies might produce cosmologically sized sheets of particles driven apart by Inflation producing ansiotropies between regions. On the other hand, to disprove this model simply requires showing the radiation from the Big Bang is purely random, this would be a weak test since these events take place before the

Recombination epoch of the Big Bang so the signal is probably lost.

## §11-4 Regions of empty space ∅

Regions of empty space should expand faster than regions of space with differentially higher energy or matter densities. This would lead to the formation of matter in empty space, and this corresponds to James Jeans' Steady State cosmology based on a continuous formation of matter in the universe.

Concomitant with this radiation in deep space must be Inflation, (and this incidently leads to Eternal Inflation) it follows that a definitative test for this model must be the formation of new matter in deep space which is expanding, where deep space is defined as being sufficiently removed from matter and sources of energy that the influence of matter and energy are negligible. This would be a strong test of the model, as the model predicts there must be new matter in deep space and that deep space is expanding at a faster rate than in the locale of matter and energy, therefore if deep space is expanding at the same rate as the rest of the universe the principle of Revolution is invalid.

Evidence of previously undetected sources of Extragalactic light has recently been observed [32], and at present it is assumed these sources are derived from stars stripped from galaxies and flung out into extragalactic regions. If these sources are determined not to arise from stars, this could be seen as strong confirmation of  Jeans' Steady State cosmology.

Another test might be possible in laboratory conditions. Imagine an evacuated container that is shielded from radiation to model deep space, and into this container a standing wave is pumped. At the nodes of the standing wave the field strength is zero, with a slight probability of Revolution of matter taking place, this would infinitesimally modulate the initial standing wave, this might be evidence of the validity of the principle, and is some circumstances actual radiation might be observed. Evidence of such radiation may have already been detected, c.f. following section on microwave photons detected in the context of the dynamic Casimir effect.

## §11-5 Monopole Suppression

In discussing the Aharonov-Bohm[24] effect Berry[4] showed for $\mathbb{R}^3$ that $\mathbb{B}$ can be written as the magnetic flux,

$$\Phi_B = \oiint_\Sigma \mathbb{B} \cdot d\Sigma = \oiint_\Sigma (\nabla \times \mathbb{A}) \cdot d\Sigma \tag{319}$$

where $\mathbb{A}$ is written in terms of the Berry connection,

$$\mathbb{A} = i \langle \psi_n \mid \nabla_R \mid \psi_n \rangle \tag{320}$$

and noting the relation to Berry's geometric phase,

$$\gamma(t) = i \int \langle \psi_n | \nabla_R | \psi_n \rangle \cdot dR = \int \mathbb{A} \cdot dR \tag{321}$$

Given $\mathbb{B} = \nabla \times \mathbb{A}$,

$$\mathbb{B} = i \nabla_R \times \langle \psi_n \mid \nabla_R \mid \psi_n \rangle \tag{322}$$

and Gauss's Theorem,

$$\oiint_\Sigma \mathbb{B} \cdot d\Sigma = \iiint_V (\nabla \cdot \mathbb{B})\, dV \tag{323}$$

By the gHH the volume in $\mathbb{R}^3$ is arbitrarily small, so the divergence theorem applies, and passing the $i$ over the Del,

$$\nabla_R \cdot \mathbb{B} = i\, \nabla_R \cdot \nabla_R \times \langle \psi_n \,|\, \nabla_R \,|\, \psi_n \rangle \tag{324}$$

since the vector identity of the triple vector product of $\mathbb{A}$,

$$\nabla \cdot \nabla \times \mathbb{A} = 0 \tag{325}$$

reduces the divergence of $\mathbb{B}$ to,

$$\nabla_R \cdot \mathbb{B} = i\, \nabla_R \cdot \nabla_R \times \langle \psi_n \,|\, \nabla_R \,|\, \psi_n \rangle = 0 \tag{326}$$

so the magnetic flux,

$$\begin{gathered}\Phi_B = \oint\!\!\oint_\Sigma \mathbb{B} \cdot d\Sigma = \oint\!\!\oint_\Sigma (\nabla \times \mathbb{A}) \cdot d\Sigma = \\ \int\int\int_V (\nabla \cdot \nabla \times \mathbb{A})\, dV = i \int\int\int_V (\, \nabla_R \cdot \nabla_R \times \langle \psi_n \,|\, \nabla_R \,|\, \psi_n \rangle)\, dV = 0\end{gathered} \tag{327}$$

This proves that no isolated magnetic flux could exist in the context of the inflationary period of the Big Bang and since an isolated magnetic flux is the definition of a magnetic monopole:

$$\begin{gathered}\text{Therefore the principle of Revolution of Matter predicts} \\ \text{that no magnetic monopoles could evolve during the Big Bang.}\end{gathered} \tag{328}$$

# §12 Abstracts of Recent Possible Experimental Evidence

## §12-1 Evidence of particle pairs was observed at the LHC in 2010 during the course of the search for the Higgs boson with the Compact Muon Solenoid (CMS).

“In high multiplicity events, a pronounced structure emerges in the two-dimensional correlation function for particle pairs with intermediate $p_T$ of 1–3 GeV/c, $2.0 < \Delta\eta < 4.8$ and $\Delta\phi \approx 0$. This is the first observation of such a long range, near-side feature in two-particle correlation functions in pp or $p\bar{p}$ collisions.”

Abstract: Results on two-particle angular correlations for charged particles emitted in proton-proton collisions at center-of-mass energies of 0.9, 2.36, and 7 TeV are presented, using data collected with the CMS detector over a broad range of pseudorapidity (eta) and azimuthal angle (phi). Short-range correlations in Delta(eta), which are studied in minimum bias events, are characterized using a simple “independent cluster” parametrization in order to quantify their strength (cluster size) and their extent in eta (cluster decay width). Long-range azimuthal correlations are studied differentially as a function of charged particle multiplicity and particle transverse momentum using a 980 inverse nb data set at 7 TeV. In high multiplicity events, a pronounced structure emerges in the two-dimensional correlation function for particle pairs with intermediate transverse momentum of 1-3 GeV/c, 2.0< |Delta(eta)| <4.8 and Delta(phi) near 0. This is the first observation of such a long-range, near-side feature in two-particle correlation functions in pp or p p-bar collisions.

Reference: [29]

## §12-2 An experiment to examine the dynamic Casimir effect spotted microwave photons originating from a superconducting quantum interference device (SQUID) oscillating a speeds 5% the speed of light.

Abstract: One of the most surprising predictions of modern quantum theory is that the vacuum of space is not empty. In fact, quantum theory predicts that it teems with virtual particles flitting in and out of existence. While initially a curiosity, it was quickly realized that these vacuum fluctuations had measurable consequences, for instance producing the Lamb shift of atomic spectra and modifying the magnetic moment for the electron. This type of renormalization due to vacuum fluctuations is now central to our understanding of nature. However, these effects provide indirect evidence for the existence of vacuum fluctuations. From early on, it was discussed if it might instead be possible to more directly observe the virtual particles that compose the quantum vacuum. 40 years ago, Moore suggested that a mirror undergoing relativistic motion could convert virtual photons into directly observable real photons. This effect was later named the dynamical Casimir effect (DCE). Using a superconducting circuit, we have observed the DCE for the first time. The circuit consists of a coplanar transmission line with an electrical length that can be changed at a few percent of the speed of light. The length is changed by modulating the inductance of a

superconducting quantum interference device (SQUID) at high frequencies (~11 GHz). In addition to observing the creation of real photons, we observe two-mode squeezing of the emitted radiation, which is a signature of the quantum character of the generation process.

Reference: [27]

## §12-3 Photon Generation from Quantum Vacuum using a Josephson Metamaterial

P. Lähteenmäki, G.S. Paraoanu, J. Hassel, and P. J. Hakonen

Abstract: When one of the parameters in the Euler-Lagrange equations of motion of a system is modulated, particles can be generated out of the quantum vacuum. This phenomenon is known as the dynamical Casimir effect, and it was recently realized experimentally in systems of superconducting circuits, for example by using modulated resonators made of coplanar waveguides, or arrays of superconducting quantum interference devices (SQUIDs) forming a Josephson metamaterial. In this paper, we consider a simple electrical circuit model for dynamical Casimir effects, consisting of an LC resonator, with the inductor modulated externally at 10.8 GHz and with the resonant frequency tunable over a range of ± 400 MHz

around 5.4 GHz. The circuit is analyzed classically using a circuit simulator (APLAC). We demonstrate that if an additional source of classical noise couples to the resonator (on top of the

quantum vacuum), for example via dissipative “internal modes”, then the resulting spectrum of the photons in the cavity will present two strongly asymmetric branches. However, according to the theory of the dynamical Casimir effect, these branches should be symmetric, a prediction which is confirmed by our experimental data. The simulation presented here therefore shows that the origin of the photons generated in our experiment with Josephson metamaterials is the quantum vacuum, and not a spurious classical noise source.

Reference: [28]

## §12-4 Evidence of undetermined sources of Extragalactic light

On the Origin of Near-Infrared Extragalactic Background Light Anisotropy Michael Zemcov, Joseph Smidt, Toshiaki Arai, James Bock

Abstract: Extragalactic background light (EBL) anisotropy traces variations in the total production of photons over cosmic history, and may contain faint, extended components missed in galaxy point source surveys. Infrared EBL fluctuations have been attributed to primordial galaxies and black holes at the epoch of reionization (EOR), or alternately, intra-halo light (IHL) from stars tidally stripped from their parent galaxies at low redshift. We report new EBL anisotropy measurements from a specialized sounding rocket experiment at 1.1 and 1.6 micrometers. The observed fluctuations exceed the amplitude from known galaxy populations, are inconsistent with EOR galaxies and black holes, and are largely explained by IHL emission. The measured fluctuations are associated with an EBL intensity that is comparable to the background from known galaxies measured through number counts, and therefore a substantial contribution to the energy contained in photons in the cosmos.

Reference: [29]

# §13 Notes and Reflections on the model

Wheeler's Grand Idea

John A. Wheeler[1] proposed a universe where a single electron travels along a myriad of worldlines back and forth over the history of spacetime, repeatedly bouncing off the initial and final boundaries; this follows from the Feynman–Stückelberg Interpretation[2] where an antiparticle of positive energy moves backward in time. The problem with Wheeler's grand idea is the lack of observable positrons; it requires an equal number of antiparticles moving backwards in time from the end of the universe, and obviously this isn't the case or the universe would be exploding all the time. This was the start point for this paper.

## §13-1 Proof that the maximal bound of Gaussian distribution must exceed the standard deviation

By inspection it can be seen the maximal value of a normal distribution is always greater than the norm of the standard deviation, for all sets of x in the vicinity of zero, since $\sigma$ is bounded above by a maximum value of $x_i$. To show explicitly that standard deviation is less than the maximal bound of a set, $\sigma < x_{\max}$ , take the definition of variance

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N} (x_i - \overline{x})^2 \tag{329}$$

expand as a Taylor series

$$(x_i - \overline{x})^2 = \mathrm{N}\, x_i^2 - \mathrm{N}\, x\overline{x} + \mathrm{N}\, \overline{x}^2 + \mathrm{O}(\ x^{\mathrm{N}}) \tag{330}$$

$$\sigma^2 = x_i^2 - x\overline{x} + \overline{x}^2 + \mathrm{N}\, O\left(x^{\mathrm{N}}\right) \tag{331}$$

$$\frac{\lim}{x \to 0} \mathrm{N}\, O\left(x^{\mathrm{N}}\right) = 0 \tag{332}$$

$$\frac{\lim}{x \to 0}\; x^{\mathrm{N}} << x^2 \text{ then } x^{\mathrm{N}} \text{ is ignorable} \tag{333}$$

reducing $\sigma^2$ in the neighbourhood of zero to

$$\sigma^2 = x_i^2 - x\overline{x} + \overline{x}^2 \tag{334}$$

$$\sigma^2 = x_i^2 - x\overline{x} + \overline{x}^2 \; < \; x_i^2 + \overline{x}^2 \tag{335}$$

order the set of x from $x_{\min}$ to $x_{\max}$ and note

$$\text{if } \overline{x} = x_{\max} \text{ then } \sigma = 0 \tag{336}$$

Whereas for

$$\overline{x} < x_{\max} \tag{337}$$

$$x_i^2 - x\overline{x} + \overline{x}^2 \; < \; x_{\max}{}^2 - x_{\max}\, x_{\max} + x_{\max}{}^2 \leq x_{\max}{}^2 \tag{338}$$

it follows that

$$\sigma^2 < x_{\max}{}^2 \tag{339}$$

or

$$|\sigma| < |x_{\max}| \tag{340}$$

Therefore for all sets of x in the vicinity of zero, $\sigma$ is bounded above by the maximum value of x.

## §13-2 Eugene Wigner' The Unreasonable Effectiveness of Mathematics in the Natural Sciences

The reasoning in this paper suggests that our Minkowski Spacetime derives its very origin from Euclidean space, and Euclidean space derives its nature from pure number, it therefore follows that what we consider to be the messy and cluttered universe is a mathematical object which is infinitely more complicated than a game of chess yet is still in its ideal form a purely logical entity. It also raises a major philosophical problem as to *what is* the singularity of the Big Bang. Treating the infinite potential well as an quantum mechanical object in itself in the same way an electron is to use Kant's epistemology *eine ding an sich*, for there is no external reference other than mathematics so I am forced to conclude our universe is a purely mathematical object. So I propose the reason why mathematics works so well as Wigner put it "The Unreasonable Effectiveness of Mathematics in the Natural Sciences", is because - we ourselves are ultimately mathematics beings grounded in a space as pure as Archimedean geometry where the rainbow is the very stuff of Euclid's dreams.

## §13-3 A Derivation of the Higgs Particle from the Geometric Potential

Since Euclidean space is non-physical and purely mathematical, I expect the Euclidean Hamiltonian to describe a massless, chargeless and spinless particle, essentially a geometric wave, so let $\mathcal{H}_{\mathrm{E}}(\phi)$ be a function of a massless, chargeless and spinless scalar field $\phi$ in $\mathbb{R}^4$,

$$\mathcal{H}_E(\phi) = \mathbb{T}(\phi) - \mathbb{U}(\phi) = 0 \qquad (341)$$

As time tends to $\mathbb{U}_{\mathrm{i}}$ the universe take the form of an infinite square potential, the ground state of which can be approximated by an inverted even quadratic Gaussian function, write $\mathcal{H}_O(\phi)$ for the ground state Euclidean Hamiltonian and call this the New Hamiltonian where $\alpha$ is an arbitrary constant,

$$\mathbb{U}(\phi) = -e^{-(\alpha\,\phi)^2} \tag{342}$$

Expanding $\mathbb{U}(\phi)$ under a Taylor series,

$$\mathbb{U}(\phi) \simeq -1 + \alpha^2\,\phi^2 - \frac{\alpha^4\,\phi^4}{2} + \frac{\alpha^6\,\phi^6}{6} - O[\phi]^8 \tag{343}$$

ignoring the constant and higher terms leads to,

$$\mathbb{U}(\phi) \simeq +\alpha^2\,\phi^2 - \frac{\alpha^4\,\phi^4}{2} \tag{344}$$

For low values of $\alpha$ and $\phi$ then -$\mathbb{U}(\phi)$ has the profile of the bottom a wine bottle.

So the New Hamiltonian becomes,

$$\mathcal{H}_O(\phi) = \partial_\mu\phi\,\partial^\mu\phi - \alpha^2\,\phi^2 + \frac{\alpha^4\,\phi^4}{2} = 0 \tag{345}$$

Rewriting the new Lagrangian and note in transforming from the Hamiltonian to the Lagrangian the potential terms are inverted again, the New Lagrangian is written $\mathcal{L}_O(\phi)$,

$$\mathcal{L}_O(\phi) = \partial_\mu\phi\,\partial^\mu\phi + \alpha^2\,\phi^2 - \frac{\alpha^4\,\phi^4}{2} \tag{346}$$

let, $\beta = \alpha^2$ and divide by two across the equation,

$$\mathcal{L}_O(\phi) = \frac{1}{2}\,\partial_\mu\phi\,\partial^\mu\phi + \frac{\alpha^2\,\phi^2}{2} - \frac{\beta^2\,\phi^4}{4} \tag{347}$$

Even though the energy in $\mathbb{R}^{1,3}$ is real it can be expressed in the form of a complex field $\phi$, and at this point I will follow closely D.Griffiths exposition of the Higgs Mechanism [30] and show a slight variant that largely has the same result. Let,

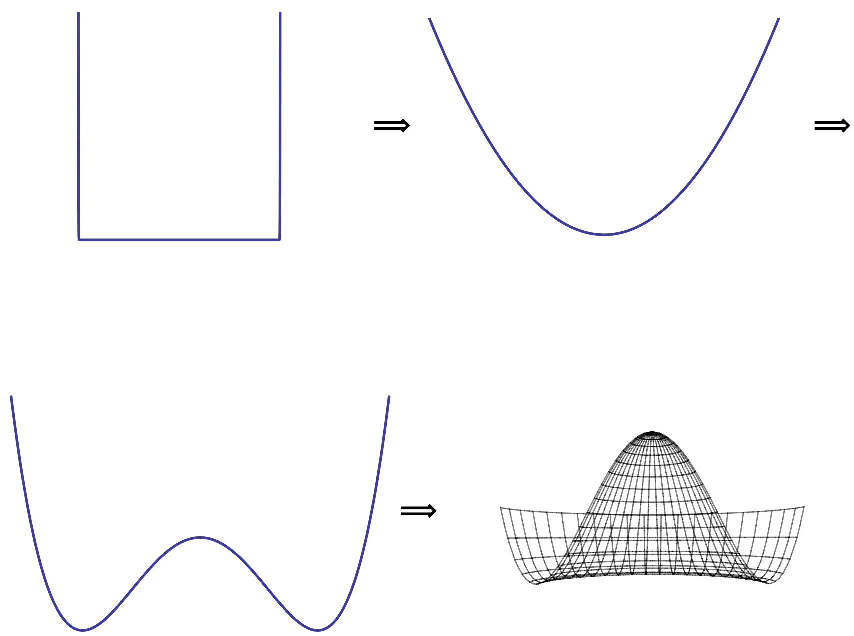
$$\phi = \phi_1 + i\,\phi_2 \in \mathbb{C} \tag{348}$$

$$\mathbb{U}(\phi) = f(\phi^* \phi) \in \mathbb{R} \tag{349}$$

this New Lagrangian can now be written,

$$\mathcal{L}_O(\phi) = \frac{1}{2}\left(\partial_\mu \phi\right)^* (\partial^\mu \phi) + \frac{\alpha^2 (\phi^* \phi)}{2} - \frac{\beta^2 (\phi^* \phi)^2}{4} \tag{350}$$

-$\mathbb{U}(\phi)$ now has the profile of the Goldstone’s Mexican hat potential, where graphically the sequence from infinite square potential to sombrero is,



To make the system invariant under local gauge transformations,

$$\phi \to e^{i\,\theta(x)}\,\phi \tag{351}$$

introduce a massless gauge field $A^\mu$ and replace the derivatives with covariant derivatives,

$$\mathcal{D}_\mu = \partial_\mu + i\,\frac{q}{\hbar\,c}\,A_\mu \tag{352}$$

$$\mathcal{L}_O(\phi) = \frac{1}{2}\left[\left(\partial_\mu - i\,\frac{q}{\hbar\,c}\,A_\mu\right)\phi^*\right]\left[\left(\partial^\mu + i\,\frac{q}{\hbar\,c}\,A^\mu\right)\phi\right] + \frac{\alpha^2 (\phi^* \phi)}{2} - \frac{\beta^2 (\phi^* \phi)^2}{4} - \frac{1}{16}\,F^{\mu\upsilon}\,F_{\mu\upsilon} \tag{353}$$

rewrite the fields as they fluctuate around the ground state,

$$\eta = \phi_1 - \frac{\alpha}{\beta} \qquad ; \qquad \xi = \phi_2 \tag{354}$$

expand $\mathcal{L}_O(\phi)$,

$$\begin{aligned}\mathcal{L}_O(\phi) &= \left[\frac{1}{2}\left(\partial_\mu \eta\right)(\partial^\mu \eta) - \alpha^2 \eta^2\right] + \left[\frac{1}{2}\left(\partial_\mu \xi\right)(\partial^\mu \xi)\right] \\ &+ \left[-\frac{1}{16} F^{\mu\upsilon} F_{\mu\upsilon} + \frac{1}{2}\left(\frac{\alpha}{\beta}\frac{q}{\hbar c}\right)^2 A_\mu A^\mu\right] - 2\,i\left(\frac{\alpha}{\beta}\frac{q}{\hbar c}\right)\left(\partial_\mu \xi\right) A^\mu \\ &+ \left\{\frac{q}{\hbar c}\left[\eta\left(\partial_\mu \xi\right) - \xi\left(\partial_\mu \eta\right)\right] A^\mu + \frac{\alpha}{\beta}\left(\frac{q}{\hbar c}\right)^2 \eta\left(A_\mu A^\mu\right) + \frac{1}{2}\left(\frac{q}{\hbar c}\right)^2 \left(\xi^2 + \eta^2\right)\left(A_\mu A^\mu\right)\right. \\ &\left. - \alpha\,\beta\left(\eta^3 + \eta\,\xi^2\right) - \frac{1}{4}\beta^2\left(\eta^4 + 2\,\eta^2 \xi^2 + \xi^4\right)\right\} + \left(\frac{\alpha^2}{2\,\beta}\right)^2\end{aligned} \tag{355}$$

This contains both the Higgs boson and the Goldstone boson, to remove the Goldstone boson use the global invariance of,

$$\phi \to e^{i\theta(\phi)}\,\phi \tag{356}$$

$$\phi \to \phi' = (\mathrm{Cos}\,\theta + i\,\mathrm{Sin}\,\theta)\,(\phi_1 + i\,\phi_2) = (\phi_1\,\mathrm{Cos}\,\theta - \phi_2\,\mathrm{Sin}\,\theta) + i\,(\phi_1\,\mathrm{Sin}\,\theta + \phi_2\,\mathrm{Cos}\,\theta) \tag{357}$$

choose,

$$\theta = -\tan^{-1}\left(\frac{\phi_1}{\phi_2}\right) \tag{358}$$

then $\phi'$ is real when $\phi_2 = 0$ then $\xi = 0$, and the new Lagrangian reduces to,

$$\mathcal{L}_O(\phi) = \left[\frac{1}{2}\left(\partial_\mu \eta\right)(\partial^\mu \eta) - \alpha^2 \eta^2\right] + \left[-\frac{1}{16} F^{\mu\upsilon} F_{\mu\upsilon} + \frac{1}{2}\left(\frac{\alpha}{\beta}\frac{q}{\hbar c}\right)^2 A_\mu A^\mu\right]$$

$$+\left\{ \frac{\alpha}{\beta} \left(\frac{q}{\hbar c}\right)^2 \eta\left(A_\mu A^\mu\right) + \frac{1}{2} \left(\frac{q}{\hbar c}\right)^2 + \eta^2\left(A_\mu A^\mu\right) - \alpha \beta \eta^3 - \frac{1}{4} \beta^2\left(\eta^4 + 2 \eta^2 \xi^2 + \xi^4\right)\right\} +$$

$$\left(\frac{\alpha^2}{2 \beta}\right)^2$$

which is all but identical to the Higgs mechanism barring the $\beta^2 = \alpha$ factor, this leads to,

$$\mathcal{L}_O(\phi) = \left[ \frac{1}{2} \left(\partial_\mu \eta\right) (\partial^\mu \eta) - \alpha^2 \eta^2\right] + \left[- \frac{1}{16} F^{\mu\upsilon} F_{\mu\upsilon} + \frac{1}{2} \left(\frac{1}{\alpha} \frac{q}{\hbar c}\right)^2 A_\mu A^\mu\right]$$

$$+\left\{ \frac{1}{\alpha^2} \left(\frac{q}{\hbar c}\right)^2 \eta\left(A_\mu A^\mu\right) + \frac{1}{2} \left(\frac{q}{\hbar c}\right)^2 + \eta^2\left(A_\mu A^\mu\right) - \alpha^3 \eta^3 - \frac{1}{4} \alpha^4\left(\eta^4 + 2 \eta^2 \xi^2 + \xi^4\right)\right\} + \tag{360}$$

$$\left(\frac{1}{2}\right)^2$$

Importantly the first term is the Klein-Gordon wave equation for a mass $\alpha$, and bearing in mind that as the energy of the system nears zero this can be approximated by minimum excitation of Schrödinger equation which is precisely by the Hartle-Hawking state, and $\mathbb{U}(\phi)$ can now be seen to be the Higgs Potential.

$$\mathbb{U}(\phi) = -e^{-(\alpha \phi)^2} \simeq +\alpha^2 \phi^2 - \frac{\alpha^4 \phi^4}{2} \tag{361}$$

So starting from the premise of Euclidean space transforming into the Minkowski Spacetime under the Wick rotation this introduces a new potential $\mathbb{U}(\phi)$ of a scalar field, upon examining the lowest orders of its expansion and taking into account global invariance of local gauge transformations leads directly to the Higgs boson, the non-physical Goldstone particle exists in $\mathbb{R}^4$ and the physical Higgs boson exists in $\mathbb{R}^{1,3}$. Importantly this is a derivation from first principles, Goldstone et al.

took this potential as an ansatz - yet for the present model the Lagrangian is imposed by the necessary assumption of a square infinite potential as an inverted even quadratic Gaussian function, so the proof is forced by the necessities of the mathematics to yield a Lagrangian that is all but identical to the Lagrangian for the Higgs mechanism. It can be seen in this model the Higgs particle is derived from the Euclidean space and not Minkowski Spacetime.

## §13-4 Heisenberg's Uncertainty principle

It can be seen Heisenberg's uncertainty principle operates on three different levels to construct an infinite system of particles in the ground state, first to construct the arbitrary shape of the well; second to require the presence of virtual particles in that ground level; and third the generalized Hartle-Hawking no boundary proposal. It follows that in a real sense Heisenberg's uncertainty principle is the physical reason for the universe, and rightly we should call this the Heisenberg Universe, although personally I prefer the title of Heisenberg-O'Brien Universe.

## §13-5 generalized Hartle-Hawking proposal

Humorously the gHH also matches Douglas Adams' Infinite Improbability Drive where every point in the universe coincides with every other point, so personally I call this the Hartle-Hawking Infinite Improbability Drive, and I could even take this further and call this the Hartle-Hawking Infinitely Improbable Boundary Drive, but at this point it's getting ridiculous, so for the purposes of this paper I simply refer to this as the gHH.

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Acknowledgements

I thank the following people for their help and wisdom over the years, to the David Teakle and his family who showed me that people and friendships are more important than science, Mitch Porter whom I had to drag over hot coals to explain these ideas, till min vän Johanna Gunnarsson från Stockholm den enda person jag någonsin visste vem kunde gå över en matta och snubblar över designen, and to Peter Murphy who is a better man than I.