Antimatter and the Big Bang

James Conor O'Brien

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Big Bang, Matter-Antimatter Asymmetry, Hartle-Hawking state[1], Wheeler-DeWitt equation[2], Feynman-Stueckelberg interpretation[3], Wick rotation[4], Tryon's zero energy universe[5], Higgs field[6], Guth inflation[7], Dynamical Casimir Effect[8]

Abstract

It is suggested that in the neighbourhood of the Big Bang at point P_o a matter-antimatter differential forms due to reflection of antimatter off the wall of an infinite, spatially shifting, potential well. Firstly the width of the potential well of a scalar field ϕ undergoes oscillation due to Heisenberg's Uncertainty Principle ranging from zero to infinity; secondly, that there is a probability also due to quantum uncertainty for an infinite sea matter and antimatter particle-pairs to spontaneously arise in the neighbourhood of the wall; and thirdly due to the Feynman-Stueckelberg Interpretation of the direction of Time being in the positive direction from P_o, that matter will move along the axis of Time away from P_o and antimatter will move the axis of Time towards P_o. This leads to the suggestion that antimatter will reflect off P_o to return in the positive time direction - thus turning the antimatter of the universe into matter in a process akin to the Dynamical Casimir Effect. It is then suggested that this instantiation of matter inflates the volume of the universe around P_o and decreases the energy density of the universe, which in turn *conflates* another generation of matter and antimatter on the surface of that volume. Thus there should exist

an epoch in the formation of the universe where purely matter is ejected from P_o and the energy density of the universe diminishes. Furthermore since the reflected fermionic antimatter collides with its matter partner under Lorentz covariance the ejected matter must be On-Mass Shell. This "inflation through conflation" continues until the overall energy density of matter of the Universe diminishes to the level where matter and antimatter is no longer conflated, and the Universe stabilizes into present era Physics.

§1 Assumptions

For the Universe $\mathbb{U}$ let P_o be the moment of the Big Bang and assume the following conditions:

$$1: \; \textit{An infinite potential well at } P_o \textit{ for a scalar field } \phi \tag{1}$$

$$2: \; \textit{The Hartle} - \textit{Hawking State is valid near } P_o[1] \tag{2}$$

$$3: \; \textit{Tryon's Zero Energy Universe near } P_o[5] \tag{3}$$

The Hartle-Hawking proposal states the ground state of a wave function obeying the Wheeler-DeWitt[2] second order differential equation holds under the Schrödinger's equation, -"this is naturally defined by the path integral, made definite by a rotation [4] to Euclidean time, over the class of paths which have vanishing action in the far past."[1].

$$\hat{\mathbb{H}}_0(\phi)\left|\phi\right\rangle = 0 \tag{4}$$

To satisfy Edward Tryon’s conjecture of a universe “as a large-scale quantum fluctuation of vacuum energy fluctuating out of zero energy”[5] let the action of the universe vanish in the “far past” prior to the Planck epoch by taking the Hamiltonian constraint of a scalar potential ϕ at $X_0 = 0$. Here $\hat{\mathbb{H}}_0$ is an operator acting on the Hilbert space of wave functions over the geometry and matter content of the entire universe; and ϕ is a functional of field configurations over all spacetime. Since we are interested in the adiabatic approximation for the minisuperspace, or the largest wavelength modes which are on the order of the size of the universe. This can be satisfied if the Euclidean Hamiltonian $\mathbb{H}_0(\phi, \mathbb{R}^4)$ is held zero in the lowest energy state

$$\mathbb{H}_0 = \mathbb{T}(\phi) - \mathbb{U}(\phi) = 0 \tag{5}$$

On applying the Wick rotation t = $-i\tau$ to $\mathbb{H}_0$ transforms between the Euclidean and Minkowski Hamiltonians $\mathbb{H}_0(\phi, \mathbb{R}^4)$ and $\mathcal{H}_0(\phi, \mathbb{R}^{1,3})$

$$\mathbb{T}(\phi) - \mathbb{U}(\phi) \underset{\leftrightarrows}{W} T(\phi) + V(\phi) \tag{6}$$

However, upon rotation into the Lorentzian manifold the Hamiltonian becomes automatically non-zero

$$\mathcal{H}_O(\phi) = T(\phi) + V(\phi) \geq 0 \tag{7}$$

To reset the equality Gravity is necessarily added as an extra potential in $\mathbb{R}^{1,3}$, as Hartle-Hawking put it - '... the total energy for a closed universe is always zero - the gravitational energy cancelling the matter energy',

$$\mathcal{H}_O(\phi) = T(\phi) + U(\phi) - G = 0 \tag{8}$$

in the process mass and time are introduced into the Minkowski action S_M

$$S_M = \int_t \left[m \left(\frac{d\,\phi}{dt} \right)^2 - V(\phi) + G \right] dt \tag{9}$$

While this model satisfies both the Hartle–Hawking and Tryon’s conjectures, it doesn’t explain the existence of matter and the absence of anti-matter. To do this, let's first introduce the scalar field $\phi(\tau)$ as a solution to the wave function of the universe as

$$\Phi = e^{-i\,\phi(\tau)} \tag{10}$$

expand Φ as a series, throw away higher order terms

$$\Phi = 1 - i\,\phi(\tau) - \frac{\phi(\tau)^2}{2} + \frac{i\,\phi(\tau)^3}{6} + \frac{\phi(\tau)^4}{24} \tag{11}$$

and throw away the imaginary terms as non-physical

$$\Phi = 1 - \frac{\phi(\tau)^2}{2} + \frac{\phi(\tau)^4}{24} \tag{12}$$

finally set $\langle\Phi\rangle$ to the zero energy condition

$$\langle\Phi\rangle = \int_{-\infty}^{\infty} e^{-i\,\phi} - e^{0}\, d^4x \tag{13}$$

This appears identical to the Higgs potential[6] in the zero energy state

$$\mathbb{U}(\phi) = -a\,\phi^2 + b\,\phi^4 \tag{14}$$

Now write our original Hamiltonian from the Wheeler-DeWitt equation as

$$\mathbb{T}(\phi) - \mathbb{U}(\phi) = K\left(\frac{d\,\phi(\tau)}{d\,\tau}\right)^2 - a\,\phi(\tau)^2 + b\,\phi(\tau)^4 = 0 \tag{15}$$

rearrange and noting that as τ tends to zero the $\phi(\tau)^4$ vanishes leaving

$$K\left(\frac{d\,\phi(\tau)}{d\,\tau}\right)_0^2 = a\,\phi(\tau)^2 \tag{16}$$

the constants (K,a) can be subsumed into α

$$\phi(\tau) = \phi(0)\, e^{\alpha\,\phi(\tau)} \tag{17}$$

Which suggests that Guth's[7] inflationary phase take place in the Higgs potential in $\mathbb{R}^4$ during the Big Bang. Since at $\tau = 0$ the Higgs potential is not at minimum energy, any perturbation such as an expansion of spacetime will send it to minimum energy, and the question immediately arises - Does the perturbation send the model into the Lorentzian manifold? To examine this first transform the scalar field under the Wick rotation into $\mathbb{R}^{1,3}$

$$\mathcal{H}_O(\phi) = T(\phi) + U(\phi) - G = 0 \tag{18}$$

$$\frac{m}{2}\left(\dot{\phi}\right)^2 - a\,\phi^2 + b\,\phi^4 - G = 0 \tag{19}$$

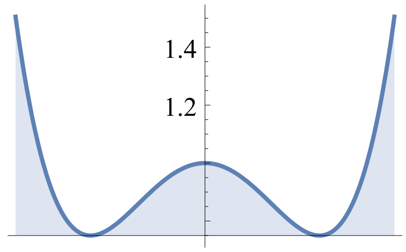
If the field grows exponentially we can apply this to approximate infinite free space where gravity is dropped, and after transforming into operator notation this can be used to a solution to the Higgs boson via the Klein-Gordon (KG) equation

$$\mathcal{H}_O(\phi) = \frac{1}{c^2}\ddot{\phi}(t) - \nabla^2\phi(t) + \frac{m^2 c^4}{\hbar^2} = 0 \tag{20}$$

This, in turn, allows us to write the universe as an infinite sea of matter in $\mathbb{R}^{1,3}$ comprised of bosons $\psi = e^{-i(-\mathrm{E\,t})}$ and anti-bosons $\overline{\psi} = e^{-i(-\mathrm{E\,t})}$. Importantly the lowest energy state is a Bose–Einstein condensate and an infinite sea of bosons can sit in the bottom of a zero energy potential. The importance of the KG lies that in the adiabatic state the system can evolve into the Schrödinger's equation as suggested by the Hartle-Hawking proposal.

Now returning to the question 'Does the perturbation send the model into the Lorentzian manifold?' At $\phi(0)$

$$\mathbb{U}(\phi) = 1 - a\,\phi^2 + b\,\phi^4 \tag{21}$$



is not at it's energy minimum, if the potential decays to it's energy minimum then as suggested in equation (17) space expands, and in this adiabatic expansion the bosons are carried to a lower energy levels where they can decay to the fermion and anti-fermion pairs $t\bar{t}$, $c\bar{c}$, $b\bar{b}$, $u\bar{u}$, $d\bar{d}$, $t\bar{t}$, $W\overline{W}$, $Z\overline{Z}$; and where the $W\overline{W}$, $Z\overline{Z}$, can in turn decay to lepton pairs of $e\bar{e}$, $\mu\bar{\mu}$, $\tau\bar{\tau}$ and muons, thus the entire particle zoo of the standard model can evolve from an infinite sea of decaying Higgs bosons during the inflationary phase. The above model proposes to combine the Hartle-Hawking proposal, Wheeler-DeWitt's equation, Guth's Inflationary universe, the Higgs field, Tryon's Zero Energy Universe into a single model, and I want to emphasize this whole process starts as a euclidean minisuperspace in $\mathbb{R}^4$ and evolves into a physical system in $\mathbb{R}^{1,3}$. I shall now attempt to show how the Feynman-Stueckelberg Interpretation[3] in the presence of a cyclic infinite potential well driven by quantum uncertainty allows for the evolution of on-mass shell matter during the inflationary phase of the Big Bang.

§2 The Universe as a Hole

In the previous section the Hamiltonian leads to an exponential growth in Euclidean space, if we now transform into the Lorentzian manifold under the Wick rotation

$$\mathcal{H}_O(\phi) = T(\phi) + U(\phi) \geq 0 \tag{23}$$

In the adiabatic state we can ignore gravity and set the equality to zero,

$$T(\phi) = -U(\phi) \tag{24}$$

which can be solved for a simple harmonic oscillator

$$\ddot{\phi}(t) = -k\,\phi \tag{25}$$

This allows us to model the entire universe as a infinite potential quantum well undergoing simple harmonic oscillation.[9] To do this first consider how particles behave in dynamic potential well. For a particle in a *static* potential well $0 \leqslant x \leqslant X$ where $\psi_n = \psi^*{}_n$

$$\psi_n = \sqrt{\frac{2}{L}}\,\mathrm{Sin}\left(\frac{n\pi}{L}x\right) \tag{26}$$

this has the probability current j_n is

$$j_n = \frac{i\hbar}{2m}(\psi_n\,\partial_x\psi_n - \psi_n\,\partial_x\psi_n) = 0 \tag{27}$$

however, for a potential well with a *dynamically* varying width where $L = X \pm \delta X$ as in an expanding universe

$$j_n = \frac{i\hbar}{2m}\left(\psi^*{}_n\frac{\partial}{\partial x}\psi_n - \psi_n\frac{\partial}{\partial x}\psi^*{}_n\right) \neq 0 \tag{28}$$

the probability current is non-zero - implying matter is somehow injected into the box and the overriding question of the universe is - how?

§2-1 Static Infinite Potential Well

Consider the virtual particle pair $\{\psi_1, \psi_3\}$ in a static infinite potential well in $\mathbb{R}^4$, where ψ_1 is the antiparticle of ψ_3 or $\psi_1 = \overline{\psi_3}$ (the choice of subscripts will become clear). According to the

Feynman–Stückelberg Interpretation ψ_1, ψ_3 evolve along the temporal axis until they reflect off $\mathbb{U}_\mathrm{i}$, where $\mathbb{U}_\mathrm{i}$ is both 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: In the neighbourhood P_o there is a point of instantiation I_o of two virtual particles

$\{\psi_1, \psi_3\}$ arise in $\mathbb{R}^4$ and they are in antiphase, and to conserve energy and momentum the energy and momentum of ψ_1 is equal and opposite to ψ_3.

Step 2: At $\mathbb{U}_\mathrm{i}$: An infinite step potential will always reflect a wavefunction away, therefore, ψ_1 transforms into ψ_2, and since ψ_1 is equal and opposite to ψ_2 in amplitude the waveforms sum to zero. Also, the retrograde momentum of ψ_1 cancels with the anterograde momentum of ψ_2, so there is also conservation of momentum and necessarily there is no positive total energy.

Step 3: After P_o : the reflected ψ_2 continues on past I_o to be relabeled as ψ_4.

Step 4: Since ψ_1 and ψ_3 are in antiphase, so ψ_1 and ψ_2 are in antiphase, ψ_2 and ψ_3 must be in phase - then it follows that ψ_3 and ψ_4 must be in phase.

Therefore the resulting positive energy particles are in phase, also, ψ_3 and ψ_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 and the universe remains static in $\mathbb{R}^4$.

§2-2 Dynamic Infinite Potential Well

Returning to Tryon's universe fluctuating into existence out of zero energy, let's model the Big Bang as a dynamically oscillating potential well where the total volume of the universe is driven over an infinite volume driven by quantum fluctuations. Most importantly it will be assumed in accordance with the Feynman-Stueckelberg Interpretation that the expansion of the well goes forward in time and a contraction is retrograde in time, and like an electron well where the walls of the well expand and contract over an infinite volume over time the walls of the potential will act as the walls in the Dynamical Casimir Effect[8].

To demonstrate how the potential well is driven over an infinite volume give this potential well $\mathbb{R}^{1,3}$ dimensions $X_i \in \{t,x,y,z\}$, and let the initial width of the potential be on the order of the Planck Length, with energy levels E_n, n is the principal quantum number; and where the ground state $|0\rangle$ is n = 1, m is mass, the energy is defined as

$$E_n = \frac{n^2 \pi^2 \hbar^2}{8 m X^2} \tag{29}$$

Let X be the width of the potential and δX_i is the variable width of the potential:

$$U(\phi) = \begin{cases} 0, & \text{if } 0 \leqslant x \leqslant X \\ \infty, & \text{outside} \end{cases} \tag{30}$$

Let the uncertainties in the width of the potential $X \simeq X \pm \delta X$ be determined by the dynamics of the potential as a quantum system in the ground state, by this I mean the particles and the potential well are combined into a single model which governs both the particles and the volume of the well. As the momentum of the system tends to zero the volume of the potential well expands ‘fleetingly’ to infinity.

To demonstrate how - treat the states of the well as a Gaussian distribution

$$X >> \delta \mathrm{X} \tag{31}$$

where X is the width of the potential and δX is the uncertainty of the width in the adiabatic state

$$\delta \mathrm{X} \geqslant \frac{\lim}{\delta \mathrm{P} \to 0} \frac{\hbar}{2\,\delta P} \to \infty \tag{32}$$

$$\delta \mathrm{X} \to \infty \tag{33}$$

$$\text{as}\, X \to \infty \text{ then } E_n \to 0 \tag{34}$$

Thus in the low energy-low momentum state the potential can be shown to be equivalent to a infinitely wide potential well in its ground state.

This allows for a generalization of the Hartle-Hawking no boundary proposal, strictly speaking the uncertainty in the boundary has -the boundary- everywhere within the potential well as opposed to placing the boundary at infinity, let's call this the generalized Hartle-Hawking no boundary proposal (gHH). Which has the surprising effect that because of uncertainty the boundary is everywhere within the box, it suggests the neighbourhood of the Big Bang was both a singularity and an infinity.

$$\text{Hartle} - \text{Hawking proposal}\, X_i \to (\infty) \tag{35}$$

$$\text{generalized Hartle} - \text{Hawking proposal}\, X_i \to (0, \infty) \tag{36}$$

Now assume the initial ground state of the scalar field is a Bose-Einstein condensate, filled entirely with an infinite sea of bosons, then as the well expands these bosons can decay to fermions and anti-fermions, these fermions can in turn reflect and recombine off the walls of the well.

The Feynman-Stueckelberg interpretation posits a negative energy particle propagating backwards in time is mathematically equivalent to a positive energy antiparticle $\overline{\psi}$ propagating forwards in time, this can be shown by noting the time dependence of a real particle's wavefunction $\psi = e^{-i \mathrm{E} \mathrm{t}}$, which on substitution for t→-t and E→-E a solution for a negative energy particle $\overline{\psi}$ can be introduced:

$$e^{(-i)(-\mathrm{E})(-\mathrm{t})} = e^{-i \mathrm{E} \mathrm{t}} \tag{37}$$

Applying the Feynman-Stueckelberg interpretation to our universe as a infinite potential well the movement through time of antiparticles is retrograde, then for an expanding volume of the universe the antiparticles are more likely to reflect off P_0 in the past, returning along the axis of time to I_o than particles moving to a future boundary would return; and as long as the universe is in an expanding phase the anterograde particles never reach the future boundary of $\mathbb{U}$ and only anti-particles (retrograde) particles reflect.

So let's introduce matter under the law of momentum,

$$p(\phi) = \sum M V > 0 \tag{38}$$

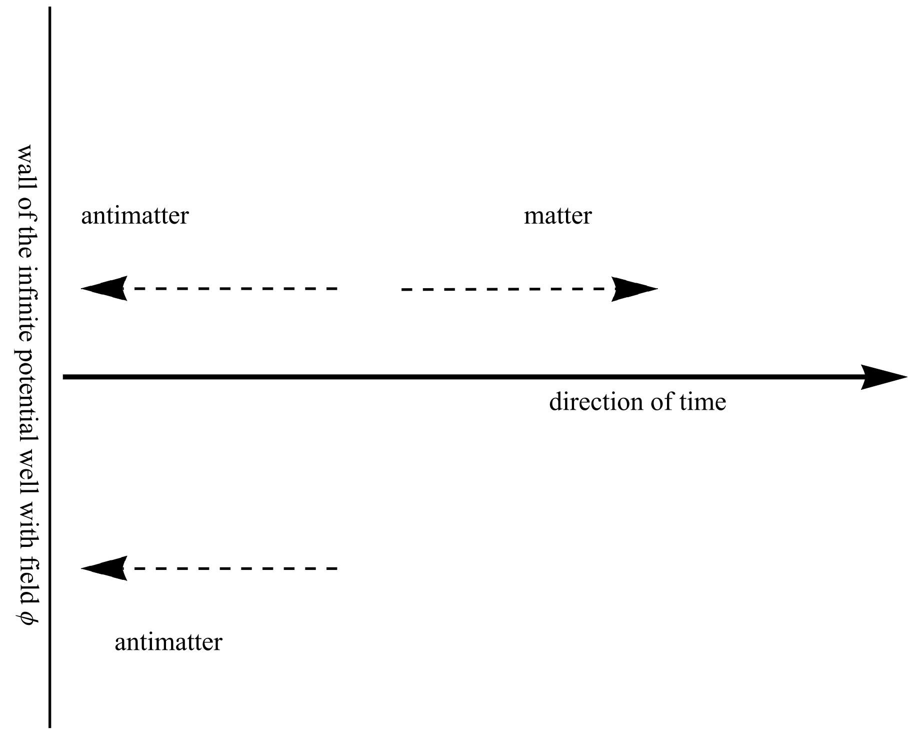
this requires the inclusion of antiparticles $\overline{M V}$ to allow for conservation of momentum

$$0 = \sum M V + \overline{M V} \tag{39}$$

$$0 = \sum M V - MV \tag{40}$$

With these equalities the spontaneous formation of particle and antiparticle within the potential well is allowed under Heisenberg's Uncertainty principle (HUP) as:

$$0 = \psi + \overline{\psi} \tag{41}$$



(42)

For each oscillation of the well, the uncertainty in spacetime shifts at all points within the potential in a cyclic manner, and the Hamiltonian requires the system never leaves the ground state, these uncertainties allow cyclic fluctuations in $\mathbb{U}(\phi)$ that results in a global phase change which is concomitant with a change in volume (it wobbles). As the system evolves the particles are carried around the ground state of the potential and the Hartle-Hawking requirement is satisfied. In the ground state the energy of the system falls to zero, so the uncertainty in the position of the boundary grows to infinity, then each point within the potential is arbitrarily close to the boundary and any particle is arbitrarily close to the boundary.

Hence, in the ground state the following observations can be made:

1) the velocity of the particles tends to zero

2) the system is adiabatic

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

4) antiparticles reflect off the past boundary and collide with their matter partners before their matter partners get a chance to reflect off the future boundary

5) there are an infinite number of particles spread over an infinite volume

The question of how a particle with zero velocity could move to a boundary is solved *by moving the boundary to the particle*, where the reflection and recombination is effectively immediate, adiabatic and universal, it is spacetime that is shifted around the particles. Importantly, since the uncertainty in the boundary decreases as the total energy increases, effectively in the near future of the Big Bang the distance from any point to a boundary is arbitrarily greater, this implies the timeline of the antiparticles travelling to the past boundary is *always less than the timeline particles travelling in the future*. Shifting spacetime around the particles eliminates the initial problem of two particles being formed at the space point in spacetime, in effect it is the reflected antiparticle from the past that moves into the region of it's particle pair that causes a collision.

What follows is the central thesis of this paper.

§3 Matter and the Big Bang

§3-1 The Revolution of Matter

As the fermions are subject to Relativistic Phase (or the Relativity of Simultaneity) the following theorem can be made:

$$\begin{gathered}\textit{if fermions } \{\psi_3, \psi_4\} \textit{ are in phase with the same velocity and energy at the} \\ \textit{same point in Spacetime} \Rightarrow \textit{ they must be in simultaneous relativistic phase}\end{gathered} \tag{43}$$

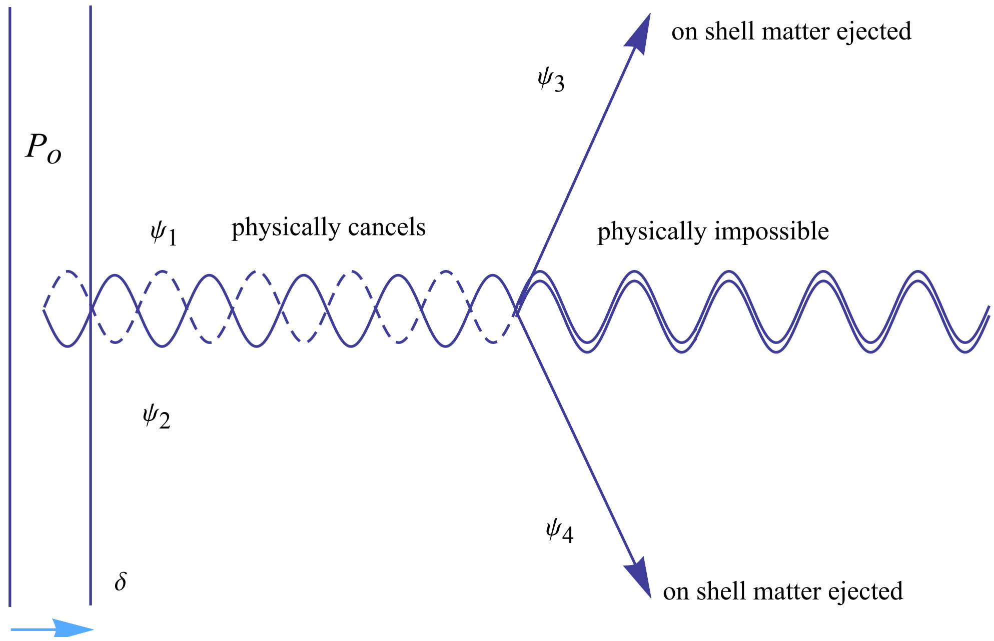
$$\begin{gathered}\textit{if } \{\psi_3, \psi_4\} \textit{ at the same point in } X_{1,3} \textit{ are in simultaneous relativistic phase} \Rightarrow \\ \textit{special principle of relativity must hold}\end{gathered} \tag{44}$$

$$\textit{if special principle of relativity holds} \Rightarrow \{\psi_3, \psi_4\} \textit{ must be on} - \textit{mass shell} \tag{45}$$

$$\begin{gathered}\textit{if } \{\psi_3, \psi_4\} \textit{ are on mass} - \textit{shell and in identical states} \Rightarrow \\ \textit{this must violate the Pauli Exclusion principle}\end{gathered} \tag{46}$$

$$\begin{gathered}\textit{if } \{\psi_3, \psi_4\} \textit{ violate the Pauli Exclusion principle} \Rightarrow \\ \textit{they must scatter off each other with an exchange of photons } \gamma\end{gathered} \tag{47}$$

$$\begin{gathered}\textit{Therefore by Lorentz covariance the exchange of photons} \\ \textit{determines that the resulting particles } \{\psi_3, \psi_4\} \textit{ must be on mass} - \textit{shell.}\end{gathered} \tag{48}$$



An examination of the diagram will reveal the change in phase at I_o (where P_o is where $\mathbb{R}^{1,3}$ begins), note how the ψ_1 and ψ_2 phases cancel exactly conserving energy for the virtual particles, and the ψ_3 and ψ_4 phases are identical and in identical 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.

It is suggested the energy for the on mass-shell particles is derived from the kinetic term in the 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 Electroweak and Strong forces,

$$\mathcal{H}_0 = \mathbb{T} - \mathbb{U} = 0 \tag{50}$$

$$\mathbb{T} = T + V \tag{51}$$

and it is the boundary of the potential well that provides the kinetic energy T to the new formed particles.

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.

Since this phase of the universe where matter is conflated and spacetime inflates is rapid and universal I call this process the *Revolution of Matter*.

§3-2 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 Hamiltonian,

$$\mathcal{H}_0 = \mathbb{T} - \mathbb{U} = 0 \tag{52}$$

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, thereupon the reflected fermion $|\psi_2\rangle$ is carried geometrically to a new point in spacetime to meet $|\psi_3\rangle$. 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 a pair of photons

$$|\psi_3\rangle + |\psi_4\rangle + |\gamma\rangle + |\gamma\rangle \neq |0\rangle \tag{53}$$

This leads us to the surprising possibility that since-under the gHH rule-each fermion is arbitrarily close to every other fermion, therefore each fermion scatters off every other fermion.

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. (54)

Hence, I propose that all fermionic species-such as electrons, quarks and neutrinos-are identical because they conflate from identical ground state bosons. 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 suggests a solution to Wheeler's grand idea of a 'one electron universe'.

§3 Summary

Start with a zero energy Hamiltonian $\mathcal{H}_{\mathrm{O}}(\phi)$ for a scalar field in $\mathbb{R}^4$ subject to simple harmonic motion

$$\mathbb{H}_O(\phi) = \mathbb{T}(\phi) - \mathbb{U}(\phi) = 0 \tag{55}$$

transform this into $\mathbb{R}^{1,3}$ under the Wick rotation and introduce gravity to re-equate the Hamiltonian to zero

$$\mathcal{H}_O(\phi) = T(\phi) + U(\phi) - G(\phi) = 0 \tag{56}$$

in the adiabatic state model this as a cyclic infinite potential well where U(ϕ) is

$$U(\phi) = \begin{cases} 0, & \text{if } 0 \leqslant x \leqslant X \\ \infty, & \text{outside} \end{cases} \tag{57}$$

fill the ground state with massive bosons ψ and anti-bosons $\overline{\psi}$ to allow for gravity in the Hamiltonian

$$0 = \psi + \overline{\psi} \tag{58}$$

the uncertainty in the width of the potential well implies position of the wall of the potential well is spread over all of spacetime

$$\delta X \geqslant \frac{\lim}{\delta P \to 0} \frac{\hbar}{2\,\delta P} \to \infty \tag{59}$$

$$\delta X \to \infty \tag{60}$$

allowing the bosons to decay to fermions (λ) throughout $\mathbb{R}^{1,3}$

$$0 = \lambda + \overline{\lambda} \tag{61}$$

the expansion of $\mathbb{R}^4$ is derived from a solution to the Higgs field in the adiabatic state,

$$\phi(\tau) = \phi(0)\, e^{\alpha\, \phi(\tau)} \tag{62}$$

and it is in the kinetic energy of the expansion that transforms the expansion due to the Feynman-Stueckelberg Interpretation that only the anti-matter fermions reflect off the wall of the potential wall in the expansionary phase and converts into matter fermions.

This leads to the observation that these reflected particles have a probability of colliding with their matter partners with an exchange of photons.

$$0 \geq \lambda + \lambda + 2\,\gamma \tag{63}$$

The resulting fermions are identical in mass, on mass-shell, and spread across an infinite volume; finally the expanded potential well is unable to collapse due to the Pauli exclusion principle and the universe continues to expand.

§4 Remarks

It can be seen this model suggests a solution to several major problems associated with the

Big Bang:

1) The problem of *materia ex nihilo* as it is suggested that the present universe is the result of an evolutionary processes, assuming before the universe there was an infinite number of mathematical spaces, and it was only those mathematical fields that lead to consistent physical laws were able to evolve into a functioning universe.

2) The problem of *cosmos ab initio* as it is implied only mathematics was present before the Big Bang, and the universe evolves out of a zero energy state.

3) The problem of the mechanism for an Inflationary universe is implicit in the adiabatic Higgs field.

4) The problem of matter-antimatter asymmetry.

5) The problem of identical particles.

6) For the ground state of an infinitely wide potential the velocity of the particles is infinitesimal, so the cyclic change in volume in the potential is infinitesimally slow and this satisfies Fock and Born's Adiabatic Theorem.

7) The volume of the universe can not collapse due to the Pauli exclusion principle as it is filled with identical fermions.

There is an interesting final note that the daughter anti-fermions might make their own potential barrier, for as they progress backwards in time they collide with each other, effectively preventing each other from progressing before P_0, and this becomes a true chicken or egg question as to whether what originated first the deep well of the universe or the infinite sea of antiparticles.

§5 Possible Evidence and Predictions

§5-1 Universally Identical Fermions: Evidence for massive particle pairs may have been 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]][10].

§5-2 During the Big Bang there must be a universal flash of light due to the simultaneous scattering of fermions, which might be evidenced in the cosmic background radiation left over from the Big Bang.

§5-3: Because this oscillating infinite potential well is similar in form to the Dynamical Casimir Effect it is to be expected that under lab conditions an antimatter-matter imbalance will observed.

§5-4: Regimes of particle-pairs should be evident in the signature of the Big Bang and during the Dynamical Casimir Effect.

§5-5: There must be the signature of a universal boson species in the Big Bang, this must have a unique signature that can be traced back to the scalar field presumably in the decay of Higgs bosons.

§6 References

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